PRINCIPLES OF FEEDING FOX AND MINK

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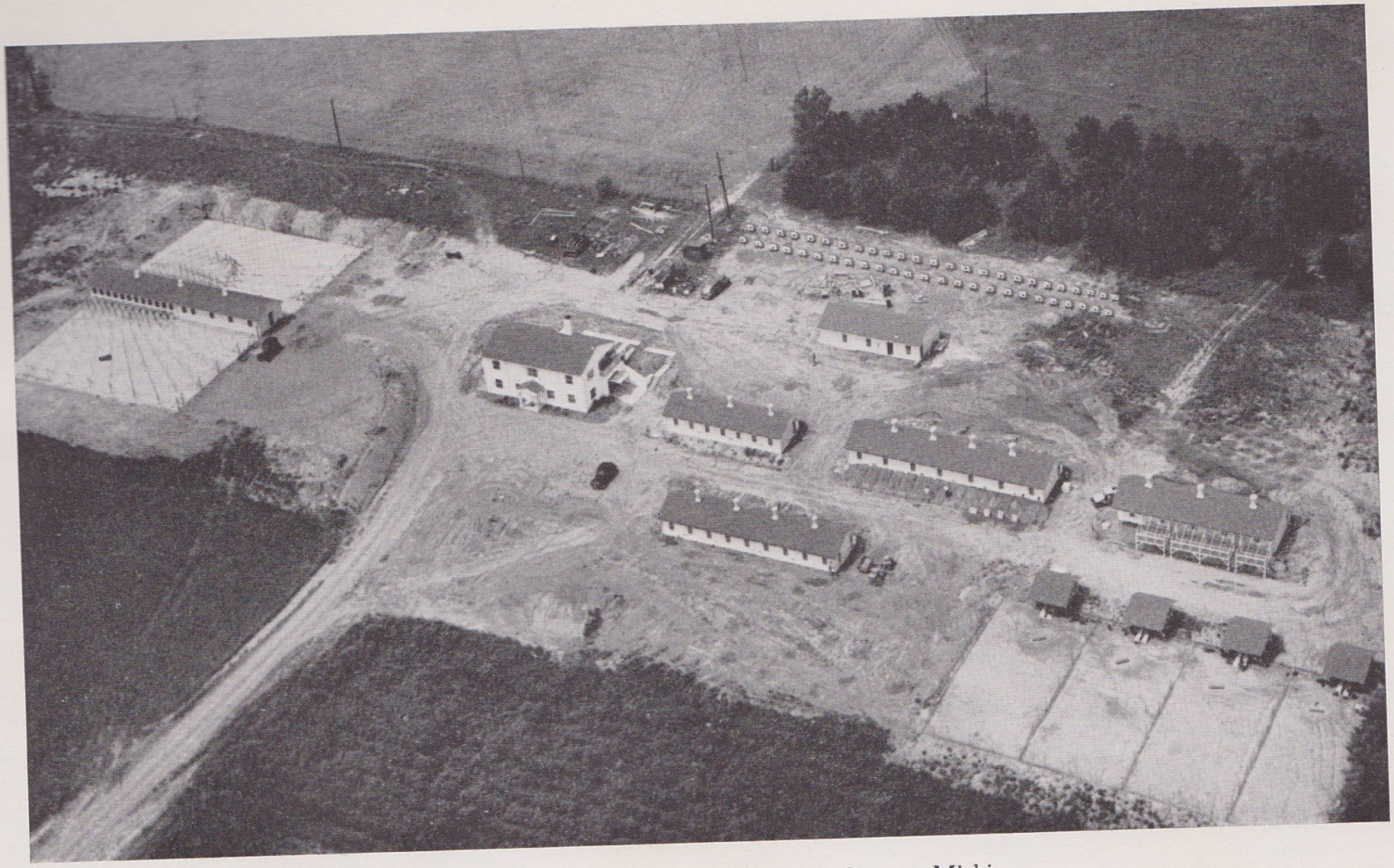
PREFACE

This book has been written as a result of the many requests from Fox and Mink ranchers for a general treatise on fur animal nutrition. Although the scope of the book is broad, many confusing points have been carefully explained and it is hoped that this book will be of value to Fox and Mink ranchers.

The Authors



The Kellogg Feed Research Farm, Hickory Corners, Michigan

Principles of Feeding Fox and Mink

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CORRECTION

Due to an error, there are mistakes on pages 2, 13 and 14 of this book. In the footnote on page 2, the name "Mattheis" should be spelled "DeMatteis". In the last paragraph on page 13, and the first paragraph on page 14, "vitamin D" should be "vitamin E."

INTRODUCTION

Since the day when the white man first set his traps on this continent, the silver fox pelt has been considered the most valuable of all the peltries. The elusive silver fox was very difficult to obtain from the wilds and a single skin was more valuable than anything else when brought to the trading post.

The credit for starting the comparatively modern industry of fox ranching must be awarded to the Canadians, for it was in the early 1870's that a pair of young silver foxes was dug out of a den in the woods near Tignish on Prince Edward Island, by a man named Thompson. This pair was sold to Benjamin Hayward, who was successful in raising a litter of pups to maturity. A neighbor, Charles Dalton (Later Sir Charles Dalton, and still later, Lieutenant Governor of Prince Edward Island), became interested and determined to become a fox breeder. He was successful in securing two wild foxes from the island of Anticosti, but these produced only crosses when bred. A black male, secured locally, was mated with a red and produced only more reds. Another pair was purchased locally in 1883, and a further pair in 1885.

Years of unsuccessful experimentation followed until the assistance of another neighbor, Robert Oulton, was enlisted, and it was on the latter's island in Alberton Harbor in 1894 that the first pens of wire netting for the ranching of foxes were erected, and here the first litter of ranch-bred silver foxes was raised to maturity.

Within a period of a few years, several men who knew either Dalton or Oulton were engaged in raising silver foxes. Notable achievements were soon made in the provinces of New Brunswick, Quebec and Ontario, and from here the industry spread to various other Canadian centers and into the more northerly states where climatic conditions are most favorable to the raising of high-grade pelts.

It is interesting to note that the early leaders in the industry derived almost their entire revenue from the sale of pelts, since the living foxes were being held for breeding purposes by members of the original combine who did not wish to sell breeding stock because they desired to control the industry. In those early days, the pelts brought from $1500 to $2600 each, and average pelts of ranch-raised foxes, when sold at auction, brought fully four times the amounts that were paid for silver foxes caught in the wild. These stupendous figures led virtually all and sundry to try their hand at this fabulous business, but then along came the first World War and most of the poorly-founded companies were forced out of existence. It was also during this period that the London market was virtually closed and this served as the necessary impetus for the development of New York as the American marketing center. Thus, an industry which started in another country has become an important agricultural enterprise in the United States.

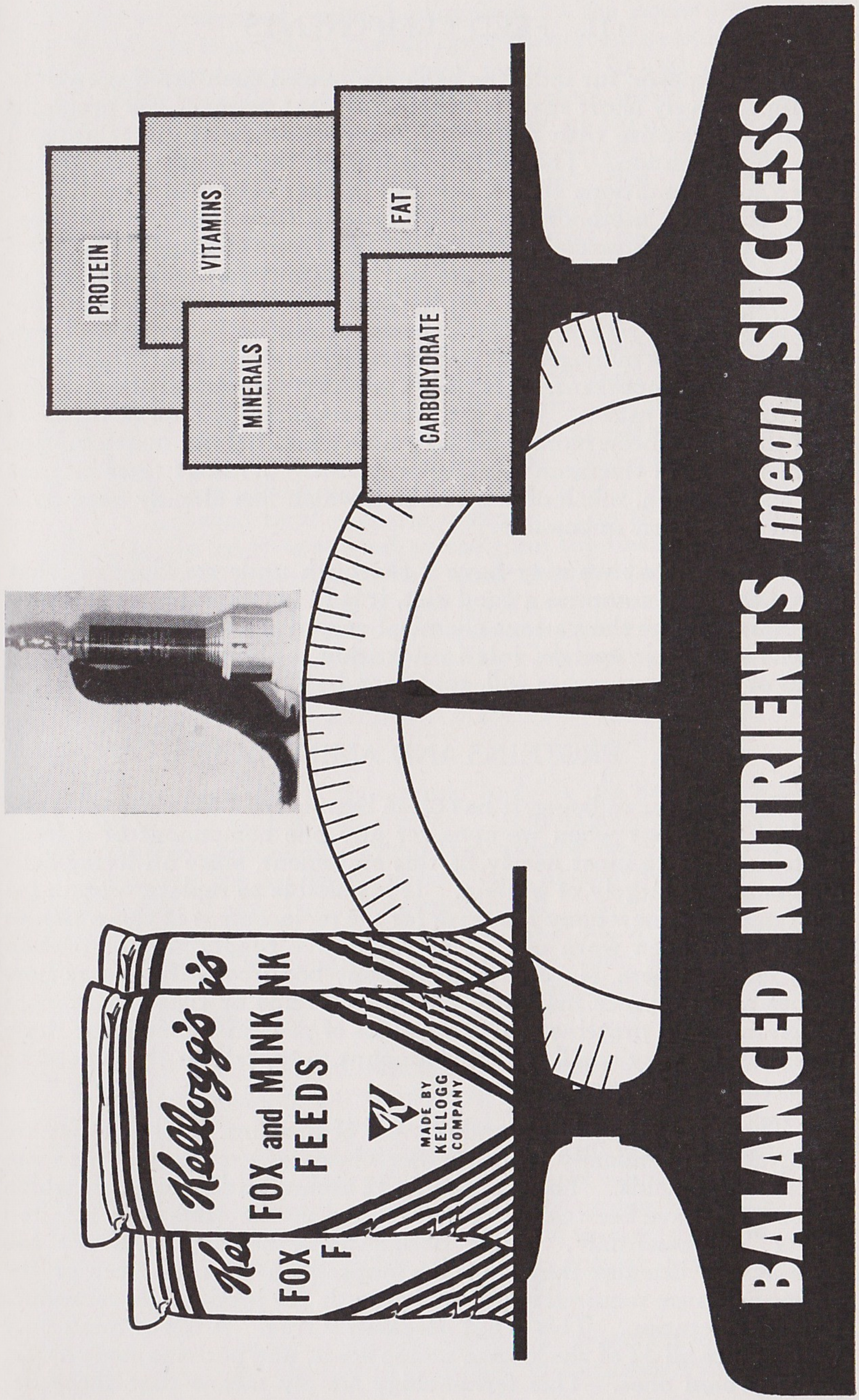
Then, about 1920, the mink-raising industry began to come into prominence when it was found that the wearing qualities of these pelts were far superior to those of the silver fox. The northern states and parts of the province of Ontario have since become very active centers of this industry. The state of Wisconsin was probably the first to promote the raising of fox and mink on a ranch scale, and because of the large amount of suitable land, capital and good climatic conditions, fur ranching has probably reached its greatest development there.

Since these two species have been raised in greater numbers than other fur bearers, it will be the main purpose of this book to treat of their nutrition and feeding.

In order to understand the principles of present day feeding of fox and mink, it would appear that the rancher should be aware of the basic components of a complete and nutritious diet and the nutritive value of the various ingredients which are used in compounding a ration. For this reason, the first section of this book deals with a consideration of the chemical components and characteristics of the various feed ingredients — proteins, fats, carbohydrates, minerals, vitamins, etc. This is followed with a section on feed sources which will serve to indicate the basic chemical composition of the various feeding stuffs in terms of the components previously outlined. With this information as a background, it will be our aim to study these factors in some detail as they apply specifically to fox and mink. This will include a summary of some of the more significant research which has been done as well as some unpublished experimental work and reports of ranch-scale feeding trials.

To conclude the work, there has been included a section entitled, "Helpful Hints" which will be of a general nature and draw upon the experience of the authors in answering various types of questions which have been asked during the course of many years of experience. It is hoped that this last section may provide the answers to some bothersome questions and may provide a ready source of miscellaneous ration information.

The mink photograph on the opposite page is reproduced through the courtesy of Mr. Albert A. Mattheis, Oakwood Mink Farm, Boyers, Pa. (The mink shown won the Championship of the Dark Natural Male Class at the 1950 North Central International Mink Show, Milwaukee, Wisconsin.)


PROTEIN
VITAMINS
FAT
MINERALS
CARBOHYDRATE
Kellogg's
FOX and MINK
FEEDS
MADE BY
KELLOGG
COMPANY
BALANCED NUTRIENTS mean SUCCESS

II. FEED COMPONENTS

The domestic fur industry has experienced such rapid growth in a comparatively short span of life that a great many of the problems which always arise with the development of a new industry are still awaiting attention. The earlier period of the industry developed under such conditions that there was neither need nor incentive to apply scientific methods for the solution of its problems. In those early times, the financial returns from pelts were so large that serious losses from poor nutrition, disease and inefficient management were of relatively small importance. At the present time, however, the situation is quite the reverse. The business of raising fox and mink now requires efficient management and economy to the utmost degree and, perhaps most important, it requires a working knowledge of what constitutes a good ration. It is a tribute to the fox and mink ranchers that they have been more than progressive and helpful in attempting to solve some of the more pressing problems. Without their interest and co-operation, much of the research which has already been done would have been impossible.

In order that we may have a thorough understanding of what ingredients will comprise a good diet, it is fundamental that we know something about the various chemical constituents of any feed component and their specific role in nutrition. Each of the five main types of feed components will, therefore, be discussed individually.

A. PROTEINS AND AMINO ACIDS

For the human being, it has often been quoted that "bread is the staff of life", but when we consider any one component of a food, proteins seem to most nearly fit this statement, since all living cells are composed largely of protein. It is possible to replace protein for the building of new body tissues or for the replacement of those tissues which have been worn out. But the active functioning of protein does not end here, since such important body constituents as hormones and enzymes may also contain proteins or those substances which make up proteins. The amounts of protein required for these uses may be very small, yet this amount may well be the difference between life and death.

There are many kinds and sources of proteins. All of them are constructed chemically from smaller chemical groupings which are called amino acids. There are some 32 amino acids known, of which at least ten have been called "essential" while the others are referred to as "non-essential". These designations, however, are not too satisfactory because they give the impression that only ten of the amino acids are required for normal growth, fur production, reproduction and lactation. This is not necessarily true. A fox or mink may well require all 32 of the known amino acids, and perhaps some as yet undiscovered ones. This terminology simply means that those de-

signated as "essential" must be supplied by the protein in the diet since the body is unable to manufacture them itself or at a sufficiently rapid rate commensurate with good growth. In this instance, the ten amino acids called "essential" are, therefore, really indispensable. Those amino acids which have received the group name "non-essential" are actually essential, the difference being that the animal body is able to carry on its own synthesis of them. For this reason, they are not required to be present as components of the protein in the diet. This division should be clearly understood and the rancher must not be deluded into thinking that certain of the amino acids are not essential to the building of body protein. Practically the entire number of known amino acids is required for the construction of the proteins comprising a human being or an animal. As the letters of the alphabet may be combined to form different words, so the 32 amino acids may be combined to form different proteins and these in turn combine to form living tissues as a whole. The pattern might well be likened to a jig-saw puzzle. In order to have the complete picture it is necessary that all of the component parts be present at the same time and arranged in the proper manner. The actual use of these proteins in the body is started at the time the food is digested. In this process of digestion the nicely constructed jig-saw puzzle is torn to pieces, and the individual amino acids are sent on their way in the blood stream and thence to every organ and tissue of the animal body. Each of these then removes from the blood stream the particular components which it needs, and from these fragments it is able to construct a new jig-saw puzzle, perhaps quite different from that in the food as it was eaten.

It is evident that if the animal body is unable to manufacture these new proteins, it cannot survive. If animals are dependent upon food for those amino acids which they cannot make, and if that food fails to supply the necessary parts of the jig-saw puzzle in adequate amounts, the puzzle cannot be completed. In such a case as this, growth cannot be normal and the processes of life will halt somewhere along the line. This condition need not be encountered if the rancher is aware of what is required to build a complete ration—and then utilizes that knowledge.

Many of the feed materials in common use do not, in themselves, contain an adequate quantity of all of these amino acids which must be supplied in the diet—the so-called "essential" amino acids—but with judicious selection of feed ingredients, a suitable mixture can be prepared which will supply all of the required amino acids with sufficient amounts of each present to give optimum nutrition. This very fact alone points to the necessity of providing a variety of protein foods in the diets of fox and mink—just as in the case of the human being.

Since the essential amino acids are distributed in varying amounts in animal and plant proteins, it is possible for meat and

cereal or vegetable proteins to exhibit a "complementary" relation where one fills in the missing amino acids of the other to produce a completed jig-saw puzzle.

The discovery that certain of the amino acids must be supplied as such by the food proteins (i.e., the essential amino acids) explains why different foods and rations having the same total protein content by chemical analysis may have entirely different values in nutrition. This means that they differ in protein quality.

B. FATS

It has always been customary to regard fat as the great provider of energy in the ration, since a given weight of fat provides more than twice the amount of energy yielded by the same weight of protein or carbohydrate. It is therefore to be expected that the amount of fat present in the diet will be of importance, since it must provide energy to keep animals warm in cold climates and also that energy which is required in the normal process of living. It is worthy of note here that fats also make a significant contribution to flavor in rations and thus may have an important effect on the palatability of the ration.

Fats differ from other foodstuffs in that they have very few forms which are soluble in water, and it is probably for this reason that an entirely different mechanism is made use of in the animal body for their transport through the wall of the intestine, into the blood stream and thence to the tissues. While other products of digestion are carried in solution, fats are transported in the blood as fine globules. In the course of digestion, fats follow the general rule of being broken down into their constituent elements, just as the proteins are broken down into amino acids. The greater portion of fat digestion takes place in the intestine, the most important factor in its digestion and absorption apparently being the bile, since, when this latter is missing, fat absorption falls to a very low level.

There is a prevailing belief among certain groups that some fats are more digestible than others; that the vegetable fats and the more recently exploited hydrogenated fats are less well utilized by the animal body than the animal fats. Results of many scientific experiments, however, have demonstrated that there is very little difference in the behavior of the great majority of fats. In general, it has been shown that those fats which melt at lower temperatures are more readily utilized.

In animals, fat may occur in all organs and tissues, and the nature of the fat stored in warm-blooded animals has been widely investigated. This stored fat in animals originates in the food, representing either material synthesized from carbohydrates or proteins, or transferred more or less directly from the fat in the intestine. Each species of animal, under normal nutritional conditions, stores a fat which is

more or less characteristic of that animal, and the chemist has been able to devise tests whereby it is possible for him to distinguish animal from vegetable fat with some degree of accuracy. It is also interesting to note in passing that, by forced feeding, the fat of the food may be transferred to the fat stores with relatively little change. However, in the course of normal nutrition, the fat stored is generally different from that of the food eaten.

Inasmuch as fats can be synthesized from other foodstuffs, the question has been raised as to whether they can be dispensed with in the diet. During recent years, however, it has been demonstrated that certain of the components of fat (the so-called "essential fatty acids") are very important in nutrition for the promotion of growth and the prevention of skin diseases. If certain of these are lacking, continued life is impossible. Under ordinary ranch conditions a fatty acid deficiency is rather unlikely, though it has been adequately demonstrated with experimental animals under laboratory conditions.

In addition to providing energy, some fats from natural sources are also important sources of the so-called fat-soluble vitamins—A, D, E and K. Fat also promotes the absorption of the fat-soluble vitamins in the digestive tract.

C. CARBOHYDRATES

This collective term includes several groups of compounds more commonly known as sugars, starches and fiber. These are more or less complex carbohydrates and cannot be absorbed as such from the digestive tract. To make them available to the animal, in a form in which they can be absorbed, they must be acted upon by digestive enzymes which break them down to smaller complexes and finally to the simple sugars. Even common table sugar (sucrose) must be broken down to its constituent simple sugars (glucose and levulose) before absorption takes place to an appreciable extent. The materials designated as "fiber" are not readily attacked by these digestive enzymes and therefore tend to pass through the digestive tract relatively unchanged, and in so doing, provide the necessary roughage of the diet. The "crude fiber" marked on the label of the feed is a measure of the amount of this indigestible material.

In spite of the fact that fats provide more energy per given weight than do these sugars, the latter are preferred sources of energy for the animal because they are more readily available on short notice for the performance of work. In case an animal ingests more usable carbohydrate than it needs at the moment, the body provides a remarkable mechanism by which these extra amounts can be converted into glycogen, or animal starch, and it is in this form that carbohydrates are stored temporarily, principally in the liver and muscles, to form a reserve supply of energy which can be used when the dietary sources fail or when there is an abnormally large demand for rapidly available energy.

Much important research work has been done in the field of carbohydrate metabolism and the processes have been shown to be very complex. The animal body has a remarkable ability to absorb, transport and utilize carbohydrates with the ultimate goal of keeping a constant and continuous supply of energy available to the body tissues. Even though we feel that we know so much about carbohydrates, a tremendous amount of additional work needs to be done before the complete story of carbohydrates in the ration and in the animal body can be learned.

D. MINERALS

There are so many mineral elements to be considered that it would be impractical to discuss them as a group. Hence, some of the more important ones will be discussed in some detail; the others merely mentioned by name.

1. CALCIUM AND PHOSPHORUS

The mineral element, calcium, acts primarily in combination with another mineral element, phosphorus, and also with a vitamin, vitamin D. In terms of absolute amounts, there is more calcium in the animal body than of any other mineral element. This large amount is concentrated mainly in the bones and teeth, though about one per cent of the total is in the soft tissues or in circulation in the blood. The problem with reference to calcium does not end here. One might say it would be impossible to have a calcium deficiency because all that would be necessary would be to meet the requirement for the species under consideration. But, at the same time, full recognition must be given to its companions—phosphorus and vitamin D. It is important that there be sufficient calcium in the diet to meet the requirement of the fox or mink, but it is likewise important that this amount bear a definite relationship to the amount of phosphorus and vitamin D provided by the diet. Different investigators have recommended calcium to phosphorus ratios varying between 1.2 to 1.0 and 2.0 to 1.0.

Calcium is relatively abundant in nature and yet can be in serious deficiency due to the fact that many of the natural forms of this element are somewhat insoluble and thus cannot be absorbed from the digestive tract. Thus, an indication on the feed label of a certain percentage of calcium does not always mean what it says insofar as the animal is concerned, since the figure on the tag is arrived at by chemical analysis. The important thing to remember is that, because of the fairly common practice of fortifying the ration by the inclusion of mineral supplements, ill-chosen supplements may seriously disturb this delicate balance between calcium and phosphorus, and thus lead to poor absorption and utilization of calcium.

2. IRON AND COPPER

No work has been done to determine the amounts of these elements required by fox and mink, but it is generally true that no proven cases of anemia due to iron and copper deficiency in these animals have been reported. The great use of iron in the body is its incorporation as part of the hemoglobin, the red coloring matter of the red blood cells. In this form it plays a most important role in carrying oxygen to every cell of the body. The iron which is not found in hemoglobin is largely present in the bone marrow, spleen, liver and intestinal wall, where it is stored pending its utilization in the formation of more hemoglobin or for incorporation into various oxidation reduction enzyme systems. The actual amount of iron required by the animal body every day is greater than that generally supplied by the diet, and this potential deficit is made up through the body's remarkable ability to recover iron from old and worn-out red blood cells. This recovered iron is then stored, mainly in the bone marrow, pending manufacture of more hemoglobin. There is also somewhat the same picture in relation to iron as is the case with calcium, since a considerable portion of the iron in foods cannot be used by the body. An analysis for total iron tells very little—the figure for AVAILABLE iron is of importance. It must also be remembered that animals vary in their ability to utilize iron—just another complicating factor—and also that there are unusual demands for iron at certain stages in the life cycle.

In order that the manufacture of hemoglobin may proceed normally in the animal body, there is a concurrent demand for copper, though none of the latter appears in the finished hemoglobin. In general, copper is found in those items in the feed supply which also contain iron, so that if sufficient iron is present in the diet, it is usually safe to assume that adequate amounts of copper are likewise present. The copper which is not required for immediate use in assisting in the formation of hemoglobin is stored in the muscles, bones and liver.

3. IODINE AND FLUORINE

As far as fox and mink are concerned, there are no data in the literature indicating the amount of iodine required, but it is generally assumed that this element is needed. The very important body substance, thyroxin, which is found in the thyroid gland, contains iodine as one of the components of its chemical structure. This thyroxin has powerful regulatory action on growth and the efficient utilization of energy from the carbohydrates, fats and proteins which have been mentioned previously.

Most of the important work on fluorine has been done on laboratory animals and with humans. It is known that fluorine is a poison to the animal body, having undesirable effects on the teeth. And yet, in spite of the fact that it is a poison in large amounts,

small traces may be required for normal tooth structure. Nature draws a very fine line of distinction between what constitutes "enough" and what is "too much". The amounts ordinarily consumed in the animal diet are safe.

4. TRACE MINERALS

There is a large number of other chemical elements about which we have no specific information applicable to fox and mink. The research work done on the requirements for these elements has been conducted for the most part, with several kinds of laboratory animals. Some of the mineral elements in this group are poisonous in excessive amounts and yet are required in minute traces for the normal functioning of the body. Among these are the following:

a. *Manganese.* When fed a diet deficient in manganese, rats and other species will fail to reproduce normally, while chicks which are on deficient diets will exhibit a peculiar deformity of the leg bones which is referred to as perosis or "slipped tendon".

b. Cobalt. Both laboratory and field experiments—the latter especially in New Zealand and Australia—reveal a definite role for cobalt in increasing the number of red cells in the blood of ruminants. Recent research shows that cobalt is one of the components of a chemical compound which shows activity characteristic of what is recognized as the "animal protein factor" complex. At the present time, it is not known whether fox or mink require the animal protein factor, and further research is needed to fully evaluate this factor for fur animals.

By special chemical and physical tests, additional mineral elements may be found in many types of feeds and feed mixtures in amounts which are almost infinitesimal. For some of these, no particular functional importance has been determined, and since they are found in very minute traces in most feed ingredients, there is no indication that additional amounts need be added to a good ration. Among these other trace elements may be mentioned *Magnesium, Zinc, Aluminum* and *Arsenic.*

E. VITAMINS

One might define a vitamin as "an essential constituent of the diet, organic in nature, and effective in playing a part in the normal functioning of tissues in amounts which are minute by comparison with those of the foodstuffs which supply the structural material and the energy." In the early days of vitamin research, they were frequently likened to catalysts because they were functional in such small amounts.

Osborne and Mendel and simultaneously, McCollum and Davis, were the first to demonstrate a fat-soluble factor clearly distinct

from the water-soluble essential of the type which had been revealed by research on certain diseases. It was largely due to the rapid improvement in the techniques of the experimental laboratory that the differentiation of other factors has proceeded so rapidly. The story may still be incomplete, although we know of quite an alphabet of vitamins at the moment, and existence of others is still suspected. There is no good reason, other than that of slight convenience, that they are still grouped under the original old headings first employed by McCollum, namely, "fat-soluble" and "water-soluble."

Inasmuch as this division is retained, it is convenient to discuss these nutritional factors under these headings.

1. FAT-SOLUBLE VITAMINS

a. CAROTENE AND VITAMIN A

Man and a wide variety of animals may exhibit disorders of health as a result of vitamin A deficiency. In general, the picture of symptoms is similar. In the young animal, growth is retarded and characteristic symptoms are exhibited in the eyes. One of the earliest signs of vitamin A deficiency observed in the eyes is night blindness. Vitamin A is required for the completion of a series of chemical reactions in the eye which are necessary for normal vision, and when it is absent this cycle is broken. This may lead to a chronic inflammation of the conjunctiva in the course of time. The eyes may also be the seat of another characteristic lesion described as xerophthalmia due to the curious dry condition of the cornea and conjunctiva. This latter is apparently a secondary condition associated with night blindness and may develop if sufficient vitamin A is not incorporated in the diet in time to prevent the damage. If remedial measures are not undertaken, this xerophthalmia may lead to ulceration and permanent damage. Also closely related to vitamin A deficiency, at least in experimental animals, is an increased susceptibility to infection, especially of the respiratory tract. All who work with animals in vitamin research know that the deprivation of vitamin A renders them more liable to infection and yet, after the effects of the deficiency have been noted, it is seldom that an improvement is observed upon the administration of vitamin A.

Some thirty years ago an association was recognized between the presence of certain yellow pigments (known as carotenoids) in plants and vitamin A activity. It was finally determined that these yellow pigments may be converted into vitamin A in the animal body.

When animal foods are considered, there is a close relationship between the amount of vitamin A stored in the animal tissues and the diet upon which that animal was raised. It should also be remembered that animal foods may contribute both vitamin A and carotene. The relative proportions of these are influenced by the diet to some extent, but largely by the degree to which the tissues of the animal

are able to convert the yellow pigments (carotenoids) into vitamin A. Both carotene and vitamin A are relatively unstable to the usual processes by which foods are preserved or cooked, though sealed cooking is preferable. They are both susceptible to oxidation and this is the reason why the container of cod liver oil or the other types of fish liver oil used by the rancher should be tightly sealed when not in use and stored in a cool, dark place. In mixed feeds, both carotene and vitamin A are slowly destroyed unless such feeds are stored at low temperatures. This type of destruction is the most common cause of depreciation in vitamin A value. With recent improvements in the techniques of drying, it is now possible to dehydrate materials rapidly and obtain a palatable and nutritious foodstuff which will supply significant amounts of vitamin A or carotene. This holds for certain types of dehydrated vegetables as well as meat products.

It is generally recognized that fur-bearing animals are able to utilize carotene to only a limited extent, and it is therefore wise to make adequate provision for vitamin A in the diets of fox and mink from such sources as liver, fish liver oils or cereal supplements properly fortified with vitamin A.

b. VITAMIN D

Scattered throughout the scientific literature on this subject there are to be found countless theories ascribing defective calcification of bones to nutritional disturbances, but the earlier literature was also replete with weighty statements tending to prove that the disease we commonly know as rickets was the result of unhygienic surroundings, hereditary influences and the like.

It remained for Professor Mellanby in England to demonstrate, in a classical series of experiments on dogs, that dietary factors were fundamentally important in ensuring normal deposition of calcium salts in developing bone. However, there were still those who maintained that lack of fresh air and sunshine were more important factors than faulty diet. Of course, after later research, it was quite easy to reconcile the different views when it was adequately demonstrated that the beneficial influence of sunlight or irradiation with ultra-violet light was a significant factor, since food mixtures which led to the production of rickets in young animals could be endowed with protective properties if they were subjected to light from the ultra-violet region of the spectrum. The change brought about in the constituents of the ration thus irradiated was found to be in the fat content of the diet. The progress of the search for this constituent is one of the most enthralling romances in modern biochemical history. The search finally led to an almost insignificant amount of a sterol, called ergosterol, and this compound, previously considered as only of the slightest academic interest, suddenly sprang into prominence as the parent substance of one of the most important dietary principles.

The physiological function of vitamin D has been extensively investigated and much valuable information has come to light. However, the fundamental fact to remember is that the laying down of mineral salts in the bone, as it develops, is determined by exactly the same laws as those which lead to the separation of lime salts from solution in water. It is now certain that the level of calcium and phosphorus in the blood can be raised to extraordinary heights by suitable dosage with vitamin D itself.

In the classical condition of rickets it has been demonstrated that, although the diet may contain ample supplies of both calcium and phosphorus, these may be imperfectly assimilated in spite of satisfactory absorption from the digestive tract. It would appear that the processes leading to retention of these elements are impaired, and that by excessive excretion a deficiency of calcium and phosphorus is brought about. In all probability, the effect of vitamin D is to increase the retention of calcium and phosphorus.

The picture presented by animals suffering from vitamin D deficiency is similar to that in animals suffering from a deficiency of calcium and phosphorus, or an improper dietary balance between calcium and phosphorus—the classical condition known as rickets.

There is no convincing evidence that vitamin D ever occurs in foodstuffs except directly or indirectly as a result of exposure to light. The majority of plant sources is very poor. However, some of the yeasts and fungi have great importance in relation to vitamin D, since they contain considerable amounts of the parent substance, ergosterol. At the present time, carefully selected strains of yeast may be grown under suitable conditions so as to provide the maximum yield of ergosterol.

In the case of animal rations, it is necessary to supply adequate amounts of vitamin D from such sources as cod liver oil, homogenized condensed fish and properly fortified cereals.

c. VITAMIN E

From time to time, research workers have attempted to rear young animals on artificial diets believed to contain all the known dietary factors. Oftentimes growth was found to be satisfactory and the general health of the animals was excellent, but when it was attempted to prolong the experiments through the reproductive period, it was found that the animals were either unable to breed or were incapable of raising to weaning age any young which might be born. It is generally accepted that a deficiency of vitamin D leads to resorption of the young fetus in the female, with consequent failure to produce living young. In the male, however, the deficiency may lead to serious degeneration of the testes and this may progress to the point of complete sterility which is irreversible.

The complete function of vitamin D in the diet, however, is unknown, although its action as an anti-oxidant along the intestinal tract is now recognized.

The chemical nature of this vitamin has been widely investigated but as yet we do not have any simple method for its determination. The best raw material sources were found in the oil derived from grain embryos, although these sources are none too constant in potency. Through chemical procedures, it is possible to concentrate the active factor to a relatively high degree.

d. VITAMIN K

This factor is known to occur in large amounts in green leaves, while smaller amounts are found in flowers, roots and seeds. Very little is known about its role in animal nutrition other than that it has an important anti-hemorrhagic effect. By this is meant that it has the ability to reduce the period of bleeding after injury, or in other words, it promotes the clotting of blood.

II. WATER-SOLUBLE VITAMINS

a. THIAMINE (VITAMIN B_1)

About twenty years ago scientists were happy in recognizing but two accessory dietary factors among the water-soluble group of vitamins. These were the so-called "Antineuritic" or "Anti-beriberi" vitamin (B_1) and the "Anti-scorbutic" vitamin (C). This situation, however, has been subjected to very drastic changes, and any complacency existing at that time was readily dispelled by the bewildering rapidity with which new nutritional factors of this water-soluble class have come to light. Vitamin C (also known as Ascorbic Acid) has retained its identity throughout the intervening years. The term "vitamin B_1" (now more commonly referred to as Thiamine) was retained for the antineuritic factor.

Animals deprived of thiamine show a number of symptoms of disordered function. One of the earliest and most outstanding is the loss of appetite. This must be remembered because many of the symptoms ascribed to thiamine deficiency are actually secondary to the failure of food consumption. In other words, some of the lesions which commonly occur—and which are usually attributed to thiamine deficiency—may, in fact, be attributed to the wastage consequent upon starvation.

The loss of appetite has been correlated with some certainty with decreased secretions of the stomach and other digestive juices, and there is evidence that one of the functions of this vitamin may be maintenance and regulation of these secretions.

There are rather definite symptoms which have been correlated with the vitamin deficiency itself. One of these is the condition commonly known as polyneuritis. Experimental studies later revealed that the cause of the convulsions seen in polyneuritis is a local disorder of the central nervous system rather than an actual degeneration of the nerve endings as was at first thought to be the case.

It is also apparent from extensive research that the deficiency of thiamine seriously interferes with the proper metabolism of carbohydrates. It seems that there is interference with the normal mechanism involved in removal or further breakdown of certain products of carbohydrate metabolism. This effect is not due merely to the failure of appetite, but is specifically related to the shortage of thiamine.

Thiamine is found in significant amounts in green plant tissues, but generally these foodstuffs are not regarded as important sources for feeding purposes. The richest plant sources are the cereal grains, wherein the vitamin is mainly associated with the embryo portion. Aside from the grains, a rich natural source is yeast and yeast extracts. The animal foodstuffs are not generally considered as of special value as sources of thiamine with the exception of pork and eggs, in which important amounts are found in the yolks.

This vitamin is relatively stable to the modern processes of cooking and preserving foods, though it is destroyed by heat, especially when moist and in the presence of alkali.

b. RIBOFLAVIN (VITAMIN B_2 OR G)

This vitamin has been given a host of names, mainly due to the fact that as each food material was investigated and found to have vitamin B_2 activity, a name was attached to it. Thus, the literature carries names such as lactoflavin (vitamin B_2 of milk), hepatoflavin (vitamin B_2 of liver), ovoflavin (vitamin B_2 of eggs), and so on. Eventually, it was discovered that all of these compounds had a similar action and the term riboflavin, which name represents its chemical structure, came into common usage.

It was originally observed that animals suffering from riboflavin deficiency suffered a loss of hair and showed irritations of the skin known as dermatitis. Many cases of deficiency have since been shown to lead to a marked degree of anemia and in many instances—especially in the laboratory rat—there is a marked occurrence, sooner or later in the course of the deficiency state, of cataracts of the eyes.

In living cells riboflavin usually occurs combined with other compounds and is able to function therefore in certain oxidative enzyme systems for the release of energy. Occasionally, in some products like milk, riboflavin is reported to be present, at least in part, in the free form.

It is abundant in those organs of the body where the most rapid chemical changes are taking place—liver, kidney and heart—and in plants is largely in the leaves and seed embryos. It is also found in more or less abundance in many common food ingredients such as milk, eggs, muscle meats, fruits, grains and vegetables.

c. NIACIN (*Nicotinic Acid*)

This substance is more popularily known as the "pellagra preventive factor" and, when it was isolated in 1937, was found to be a compound long known to the organic chemist—namely, nicotinic acid. The simpler name, niacin, has come into more prevalent use during recent years.

Pellagra is generally considered to be a dietary deficiency of ill-fed people, but is recognized at present by most scientists as a complex deficiency. In other words, the diet is lacking in more than this one dietary essential. It has been shown that a relationship exists between niacin and tryptophane and that the high incidence of pellagra in the Corn Belt is not wholly due to low niacin but also because the corn proteinization is low in the amino acid, tryptophane. The disease, pellagra, usually affects the skin in a symmetrical pattern and it becomes rough, scaly or horny. It also affects the digestive tract and the lining of the mouth; the tongue and the stomach may become swollen and ulcerated. Deficiency may also result in a lack of hydrochloric acid in the stomach, thus interfering with normal digestion, and may lead to a very severe diarrhea. The deficiency state also shows some effects on the nervous system. The entire picture of pellagra is one of an incomplete diet, and the results of the direct administration of niacin or niacinamide, the preferred form, alone are very dramatic, though the extent to which improvement occurs is also limited by the existence of other vitamin deficiencies in the diet.

Food ingredients which are considered as good sources of this factor include meat, fish, yeast, meat scrap, enriched bread and whole grain cereals. Some species of animals, among them the rat, cow and chicken, do not appear to require *dietary* niacin under ordinary circumstances. Apparently these species obtain sufficient niacin either through actual synthesis in the body tissues or through synthesis of the factor by micro-organisms in the digestive tract.

d. PANTOTHENIC ACID

This vitamin is extremely widespread in occurrence as its name "from everywhere" implies. The best sources include egg yolk, liver, kidney, meat scrap, dried whey, yeast, milk, buttermilk, rice bran, molasses, lean meat, cereal grains and then, in smaller amounts, certain vegetables.

The complete role of this vitamin has not been worked out for all animals and its functions still remain obscure. Rats, mice and silver foxes, deficient in pantothenic acid, develop a gray-hair condition, scientifically known as "achromotrichia."

e. PYRIDOXINE (*Vitamin B6*)

This vitamin has also received the name "adermin" because of its ability to prevent the occurrence of a typical skin disease in rats. It is thought to be involved in the utilization of the unsaturated fatty acids and in certain reactions involved in the proper metabolism of proteins.

It prevents the typical skin condition in rats which has been termed "acrodynia", a characteristic anemia in dogs and pathological changes which occur in the heart muscle and spinal cord of rats. Rats, dogs and pigs which have been deprived of pyridoxine exhibit fits closely resembling epileptic fits in the human. Among sources of this vitamin are egg yolk, wheat germ, yeast, liver, milk, muscle meats, kidney, legumes and whole grains.

f. BIOTIN

This factor has become popularly known as the "anti-egg white injury factor" and is one vitamin which possesses such a remarkable potency that one part in four hundred billion will stimulate the growth of certain yeasts. The biochemical role of biotin has not yet been clearly defined although it is believed to be involved in the metabolism of fats. Deficiency in the rat results in a typical skin disease unlike those already referred to as occurring in pellagra or in pyridoxine deficiency, and in addition, rats develop a typical loss of hair around the eyes—the so-called "spectacle eye" condition. The distribution of this vitamin among various products is such that liver, kidney, eggs, vegetables, grains, nuts, milk and yeast are all considered suitable sources of the factor.

g. FOLIC ACID (*Pteroylglutamic Acid, Vitamin Bc*)

As late as the middle of 1945 this factor was just another member of the group of vitamins classified as new and unidentified B-complex factors. The story of this vitamin is only about ten years old and developed when research workers discovered an unidentified factor present in certain crude foods which stimulated growth. Extensive studies soon ruled out the possibility that this factor was identical with any of the existing vitamins. The folic acid picture has been very much complicated by the large number of similar, and possibly identical, factors postulated by various research groups. It has been common to refer to this group of factors at the present time as "Pteroyglutamic acid", though for the purpose of this discussion, perhaps the simpler name "folic acid" is preferable.

It has been found in a wide variety of foodstuffs among which may be mentioned liver, yeast, cereal grains (wheat, malt sprouts, oats, corn, polished rice, rice bran, linseed meal, alfalfa meal and soybean meal), fish meal, grass juice, spinach, egg white and yolk, bone marrow, meat scrap, milk powder and whey.

h. PARA-AMINOBENZOIC ACID

This compound has been known to the chemist for about 85 years, but it was only about seven years ago that its status as a vitamin was postulated. In 1941, scientific studies revealed that it played a role in the nutrition of rats and chicks. Its role in the nutrition of animals is still rather obscure, however, and its function as a vitamin has been the subject of controversy for several years. Among sources of para-aminobenzoic acid are the following: yeast, rice bran and polishings, whole grains and grain embryos (e.g., corn and wheat germ), molasses and such materials as are generally considered good sources of the other B-complex vitamins.

i. CHOLINE

This is another comparative newcomer to the family of B-vitamins and, in fact, there is a feeling among some research groups that it should not be classed as a vitamin because the amounts required in the diet are comparatively large according to the accepted definition of a vitamin. It has been shown capable of preventing and curing fatty livers and certain types of liver damage and also is a factor in the curing of hemorrhagic kidney disease in young rats. In addition to being available in commercial quantities, it is found in liver, heart, kidney, soybeans, meat scrap, sweetbreads, brain, egg yolk, tongue, yeast, fish, fruits, grains, milk, roots and green leafy vegetables.

j. INOSITOL

The chief known role of this factor is the prevention of loss of hair in mice, though it may also be a factor in stimulating proper motility of the stomach and intestines and may be a regulator of some phases of fat metabolism. The synthetic product is available, and it is also found in yeast, whole grains, milk, meats, fruits and vegetables.

k. ASCORBIC ACID (*Vitamin C*)

For many centuries, scurvy in humans was recognized, even though vaguely, as a deficiency disease, and accounts of the ravages of this disease were recorded as long as two hundred years ago. Experimental work in the laboratory was largely confined to studies with the guinea pig, when it was found that this animal will develop a condition almost identical with human scurvy when maintained on a vitamin C-deficiency diet for a period of several weeks.

Hemorrhages may occur in many areas, the bones become very brittle and will fracture readily, the teeth loosen and the bone joints in the ribs become enlarged.

The part played by ascorbic acid in assisting to maintain the normal state of affairs in the body is not known. Some species of animals are able to subsist on a diet devoid of vitamin C for long periods of time without showing signs of a deficiency, while others will develop scurvy in a comparatively short time. The rat and dog belong to the former class, while man and the guinea pig are representatives of the latter. As far as is known at the present time, the fox and mink also belong to that group of animals which require no dietary sources of ascorbic acid.

1. ACCESSORY FACTORS

Among this group of less well-defined factors which apparently are required by one or more animal species are several for which the chemical and physiological properties are not yet completely known.

It has become apparent from work with chickens and swine that there is a factor(s) present in certain common feeds required for normal growth and efficient utilization of the nutrients of the diet. This has been called the "animal protein factor." It is found in fresh meat, fresh fish (whole), tankage, homogenized condensed fish, fish meal, fish solubles and, to some extent, in milk and milk products.

As part of this complex, vitamin B_{12} has been isolated and has been found to contain the mineral element cobalt, to which reference is made in an earlier section of this book, under the heading Minerals. Until further research has been conducted, the "animal protein factor" cannot be fully evaluated for fur animals, although it is evident from recent investigations carried on at Wisconsin that both the fox and mink require unidentified factors present in liver and milk for the fox and in liver for the mink. They have also shown that another factor, important in mink nutrition is present in dessicated hog mucosa.

III. FEED SOURCES

From its food, the animal body obtains those substances which become a part of its structure, which yield the energy for its normal body functions and which serve to regulate the essential processes of life and health. Thus, the first section of this work has presented the various types of materials which the animal body receives from its food supply. However, this information needs to be expanded so that it will become evident which of these necessary nutritional factors are supplied by what foods and in what amounts. This is where the analytical chemist in the laboratory enters into the picture. By certain types of chemical analyses it is possible for the chemist to tell us just how much protein, fat, moisture, fiber, vitamins, carbohydrates and minerals there are in the various possible feed ingredients. In order to be able to use feed ingredients intelligently, such information as this is most essential. In fact, the chemist has even gone so far in some instances that he can tell not only how much total protein is present in a food ingredient, but also can tell us the amounts of the various amino acids present.

In the usual chemical analysis of a feed ingredient—or a total ration— the chemist will proceed to determine the amount of moisture present and then will carry out determinations of protein, fat, ash (or mineral matter) and fiber (indigestible carbohydrates). Then he totals these figures and subtracts the sum from 100. The difference he calls nitrogen-free extract, which is usually designated N.F.E. for the sake of convenience. This fraction represents the digestible carbohydrate of the material, and it is most convenient to determine it by difference since methods involved in testing for all of the individual carbohydrates are too laborious and time-consuming. If additional data are desired, the chemist also has appropriate methods for the determination of the individual fractions of the mineral matter, or ash content, such as calcium, phosphorus, iron, copper, etc.

It will be noted that no mention of vitamins has been made in the enumeration of those things for which the chemist generally analyzes a feed or feed ingredient. Vitamins are normally present in such small amounts that they are neglected in making the usual types of chemical analysis (the so-called "proximate analysis") and special methods are used for their determination. Since these amounts are so small, no account need be taken of them in calculating the content of the various major fractions such as moisture, protein, fat, ash, fiber and N.F.E., but their presence in adequate amounts and balance should be assured through the inclusion of ingredients which contain desirable amounts. The tables of analysis presented in the following pages will cover most of the important ingredients of fox and mink rations and a few others of more or less general interest. By using such tables as these, it is possible to work out various combinations which would give a certain total analysis for

protein, fat, etc. With a full knowledge of this sort of information and a good sharp pencil, the chemist can tell you whether a given diet formula is going to supply enough protein, or other nutriment, for the animals being considered.

It is important to mention again that such an analysis will not always provide an answer to the NUTRITIONAL VALUE of a feed or feed mixture. This is especially true in the case of the proteins, as has already been pointed out. There are numberless possible combinations which would provide the correct amino acids in the proper ratio to one another to provide complete protein nutrition for a fox or mink. This, shall we say, "art" of successfully combining these factors is the task of the nutritionist or biochemist.

MEAT AND MEAT BY-PRODUCTS

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Beefmeal	8.0	70.6	9.1	13.0	0	0	5.24	2.61
Blood, dried	8.8	82.2	1.2	3.8	1.3	2.7	.33	.25
dried, soluble	6.0	88.7	0.7	3.3	0.6	0.7	.68	.50
liquid, horse	71.3	19.2	0.07	0.89	—	8.54	.013	.002
Bloodmeal	14.4	84.5	1.1	4.5	1.0	0.7	.33	.25
Bone, flour	2.5	7.3	2.6	83.0		4.6	33.	15.
green — beef	50.0	5–10	5–10	30–40				
— horse	59.0	19.2	0.4	20.4	0	0		
marrow — beef	3.3	2.2	92.8	1.3	0	0.4		
— pork	14.6	2.3	81.2	—				
Bonemeal, raw	6.0	25.8	2.9	61.6	0.8	2.9	23.05	10.22
steamed	3.1	6.2	2.2	83.6	1.3	3.6	28.8	13.34
steamed	3.6	7.1	3.3	81.3	0.8	3.9		
Brains, beef	80.6	8.8	9.3	1.1		0.2	.008	.38
pork	75.8	11.7	10.3	1.6		0.6		.342
Calf Heads	62.6	10.3	17.8	1.1		(9.2)*		
Calf Tongue Trimmings	63.3	10.9	18.5	1.7		(5.6)*		
Cheek Trimmings, beef	68.0	16.0	15.0	1.0				
Cow Bags (udders)	65.4	12.3	13.3	0.4		8.6		
Esophagus and Windpipe								
— beef	76.6	10.4	6.7	1.3		(5.0)*		
— beef	77.1	18.5	4.0	0.8				
— calf	69.0	11.2	11.2	1.2		(7.4)*		
Fox, carcass	65.9	19.9	10.0	4.2				
Gullets, beef	55.0	16.7	5–10	1.8-2.5			.009	.172
Heart, beef	62.6	16.0	20.4	1.0		0.36		
veal	73.2	16.8	9.6	1.0		0.1	.009	.389
sheep	69.5	16.9	12.6	0.9		0.4	.01	.236
pork	75.6	17.1	4.8	1.0		7.0		
Horse meat, lean	75.1	14.3	2.6	1.0		1.0		
lean	74.0	20.0	4.0	1.0		1.3		
lean	74.5	18.6	4.1	1.5		1.4		
fat	63.9	18.0	15.8	0.9		(0.9)*		
viscera	77.0	19.8	1.2	1.1		(3.2)*		
viscera	78.0	16.0	1.5	1.3		0.9	.016	.287
Kidneys, beef	76.7	15.0	4.8	1.5		6.6		
beef	71.8	10.7	9.9	1.0			.009	.171
veal	75.8	16.9	6.4	1.3		0.3	.013	.254
sheep	78.7	16.5	3.2	1.3		0.8	.016	.287
pork	77.8	15.5	4.8	1.2		0.4		
Lips, beef	67.4	18.0	13.5	0.7				
ox	71.0	19.0	9.5	1.5		9.0	.012	.22
Liver, beef	70.4	14.1	5.0	1.5		0.7		
beef	73.0	20.4	4.5	1.4		4.0	.011	.205
veal	70.0	19.0	5.3	1.3		5.0	.013	.249
sheep	61.2	23.2	9.0	1.7		1.4	.008	.368
pork	71.4	21.3	4.5	1.4		2.4	.62	1.27
Livermeal	6.4	67.2	14.6	7.5	1.4		.015	.173
Lungs, beef	79.7	16.4	3.2	1.0			.017	.173
horse							.01	.160
veal	76.8	16.1	5.0	1.1			.013	.255
sheep	75.9	20.2	2.8	1.2			.012	.153
pork	83.3	11.9	4.0	0.9				

* Indicates a figure for total carbohydrates (i.e., N.F.E. plus fiber)

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Meat & Bone Scraps or Dry Rendered Tankage with Bone								
— 50% protein grade	6.2	50.8	11.1	27.8	2.1	2.0	10.0	5.0
— 45% protein grade	6.4	45.9	11.7	31.1	2.2	2.7	11.0	5.5
Meat Scraps								
48–53% protein	5.7	51.0	12.0	28.0	1.6	1.7	9.71	4.81
53–58% protein	6.3	55.0	9.1	26.7	2.2	0.7	8.0	4.0
Mink, carcass	63.7	18.6	13.0	4.7				
Muscle Meat, beef	69.7	21.9	7.4	1.0			.012	.222
veal	71.0	20.3	7.7	1.0			.015	.223
sheep	47.6	15.6	30.9	1.1			.021	.18
pork	48.0	16.9	30.1	1.0			.008	.156
Ox Tails	58.1	14.9	13.8	5.2	(8.0)*			
Rabbit Meat	66.9	20.4	11.7	1.1			.011	.199
	66.7	21.5	9.8	1.2		0.8		
Salivary Glands	57.9	8.3	27.4	0.6	(5.8)*			
Spleens (Melts)								
— beef	77.1	18.4	2.5	1.4	0	0.6		.284
— pork	79.0	17.3	1.9	1.4	0	0		.298
Stomach, Ox	81.1	16.6	2.1	0.2	0	0		.040
Pork	74.0	16.5	8.9	0.6	0	0		.118
Suet, Beef	13.7	4.7	81.8	9.3			.006	.007
Tankage								
60% protein grade	7.8	61.3	8.8	19.2	1.4	1.5	6.37	3.23
55% protein grade	7.3	56.0	10.1	22.0	2.0	2.6	7.33	3.93
50% protein grade	7.8	50.3	11.3	25.9	2.0	2.7	10.97	5.14
45% protein grade	6.0	46.5	10.6	32.7	2.0	2.2	11.21	4.88
Under 45% protein	5.7	38.9	17.1	28.9	2.9	6.5	13.49	5.18
Tripe, Beef	86.5	11.7	1.2	0.3		0.3	.009	.042
Beef	75.7	9.6	9.4	0.6	(4.7)*			

FISH AND FISH PRODUCTS

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Carp, canned	72.4	12.9	11.3	2.4	0.6	0.4		
fresh	72.5	13.1	11.4	2.3	0.5	0.2		
Cod	85.0	11.1	0.2	1.2	1.5	1.0	.014	.188
	82.6	16.5	0.4	1.2				
Fish Meal	10.0	51.0	8.5	28.0	0.7	1.8	4.14	2.67
	7.1	62.0	7.3	17.7	0.6	5.3		
	7.7	58.7	7.9	20.7	0.9	4.1		
Haddock	79.0	17.2	0.3	1.1	0.9	1.5	.017	.173
	81.7	17.2	0.3	1.2				
Hake	83.1	15.4	0.7	1.0			.026	.259
Halibut	75.2	18.6	5.2	1.0			.008	.2
Herring	71.9	19.5	7.1	1.5			.012	.152
Homogenized Condensed Fish	45.0	30.0	5.0	8.0	0.5	11.5	.945	.61
Mackerel	73.4	18.7	7.1	1.2			.015	.261
Menhaden Fish Meal	8.2	56.3	9.2	20.2	0.9	5.2	5.30	3.38
Mullets	74.9	19.5	4.6	1.2			.026	.22
Sardine Meal	6.5	64.5	9.8	15.2	0.2	3.8	4.21	2.54
Smelt	72.5	16.5	4.2	4.7	1.0	1.1		
	71.0	16.5	4.1	4.9	2.0	1.5		
	79.2	17.6	1.8	1.4			.019	.202
Whiting, fresh	72.5	19.5	7.1	1.5				
	71.0	18.8	4.0	5.4	1.7		.028	.128
	79.3	15.7	4.4	0.9				
canned	71.4	16.8	3.9	5.0	0.5	2.4	.042	.189
ground and cooked	62.0	22.8	5.5	8.2	0.6	0.9		

* Indicates a figure for total carbohydrates (i.e., N.F.E. plus fiber)

CEREAL AND GRAINS

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Alfalfa meal	8.1	15.2	1.9	8.5	28.4	37.9	1.32	.19
leaf meal	8.5	20.9	2.6	14.4	15.7	37.9	1.69	.25
leaf meal	7.0	22.0	3.5	13.0	(41.0)*			
Barley feed	9.9	13.2	3.5	4.0	8.4	61.0	.03	.40
Beet Pulp, dried	8.0	9.0	0.8	3.5	18.8	59.9	.67	.08
Brewers Grains, dried								
18–23% protein	7.9	20.7	7.2	4.1	17.6	42.5		
23–28% protein	7.7	25.4	6.3	4.3	16.0	40.3	.29	.48
Corn, cooked & flaked		7.7	0.28		0.35		.008	.056
distillers grains dried	6.4	30.6	10.6	2.9	10.8	38.7	.04	.30
germ meal	7.0	19.8	7.8	3.3	8.9	53.2		.58
gluten feed	—	23.0	2.5	—	8.0	51.0	.48	.82
gluten meal	—	42.0	1.5	—	5.0	38.5	.13	.38
hominy feed	9.1	11.0	6.9	2.7	4.8	65.5	.22	.71
oil meal (expeller)	8.8	23.8	1.8	2.4	11.3	52.3	.05	.45
whole, yellow	13-17	6.6-8.6	.33-1.8	.2-.6	(71.9-76.6)*		.01	.02
yellow, meal	11.5	9.2	1.9	1.0	(76.4)*			
Linseed Oilmeal								
solvent process	9.6	36.9	2.9	5.6	8.7	36.3	.35	.75
solvent process	8.5	40.5	5.7	5.3	(40.0)*			
Malt Sprouts	—	24.0	1.5	—	15.0	48.1	.18	.7
Molasses, cane	25.9	2.8	—	9.4	—	61.9	.273	.051
beet pulp, dried	8.2	9.9	0.7	5.2	15.9	60.1	.67	.08
Oats, flour	8.0	15.0	5.8	1.9	2.6	66.7		
groats	—	16.0	6.0	—	2.4	64.0	.10	.45
meal or rolled oats (feeding)	8.5	16.3	5.9	2.4	2.8	64.1	.10	.45
pulverized	7.7	12.5	4.4	3–5	12.0	59.9	.09	.34
Rice, bran	8.9	12.8	13.4	10.8	13.0	41.1	.08	1.36
cooked & flaked		6.7	0.28		0.21		.011	.10
brown	9.8	8.9	2.0	1.1	1.0	77.2	.04	.25
polishings	9.5	12.7	11.5	6.1	3.0	57.2	.04	1.10
Rye, flour	11.6	8.3	1.3	0.9	0.6	77.3	.02	.28
Soybean Oil Meal								
hydraulic or expeller process	8.3	44.3	5.7	5.7	5.6	30.3	.31	.68
hydraulic or expeller process	6.9	49.9	6.2	5.5	5.1	26.4	.29	.66
solvent process	8.4	46.4	1.6	6.0	5.9	31.7	.30	.66
Wheat bran	9.4	16.4	4.4	4.0	9.5	58.9	.14	1.29
brown shorts	9.9	17.8	4.7	4.4	6.2	57.0	.10	.90
cooked & flaked		9.9	1.8		2.1		.074	.55
dried bread	13.2	11.4	1.0	2.0	0.4	72.0		
germ meal		31.1	9.7		2.6	42.2	.08	1.11
gray shorts	11.0	17.5	4.4	4.1	5.4	57.0	.13	.84
middlings	10.4	17.0	4.3	3.9	5.4	59.0	.09	.93
mixed feed	9.9	18.2	4.4	4.4	6.9	56.1	.11	1.09
red dog	11.1	18.3	3.4	2.2	2.3	62.7	.07	.51
whole	10.6	12.0	2.0	1.8	2.0	71.6	.04	.39
whole	8.1	11.1	1.7	1.8	(77.3)*			
Yeast, dried brewers cells	4.3	48.5	0.5	10.7	0.5	35.5	.13	1.56

* Indicates a figure for total carbohydrates (i.e., N.F.E. plus fiber)

FRUITS AND VEGETABLES

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Beets, sugar	78.0	1.5	0.1	1.0	2.9	16.5	.030	.049
Cabbage, whole	90.6	2.2	0.3	0.9	1.0	5.0	.07	.04
Carrots, roots	88.1	1.2	0.2	1.2	1.1	8.2	.046	.038
whole, raw	89.6	0.9	0.3	0.8	0.9	7.5	.044	.037
whole, raw	89.4	1.2	0.3	0.9	1.1	7.2		
whole, raw	87.1	1.1	0.4	1.0	1.1	9.3		
Figs, dried	11.5	4.3	0.3	2.4	7.3	74.2	.162	.116
Lettuce	94.0	1.2	0.3	0.9	0.7	2.9	.016	.020
Potatoes, white	78.9	2.1	0.1	1.0	0.6	17.3	.012	.053
white	77.9	2.2	0.1	1.0	0.4	18.4		
sweet	71.1	1.5	0.4	1.0	1.3	24.7	.024	.039
Raisins	12.8	2.6	3.3	3.4	1.7	76.1	.04	.126
	10.6	9.6	7.8	5.3	16.1	50.6		
Tomatoes, canned	94.0	1.2	0.2	0.6	0.3	3.7	.006	.019
dried pomace	5.7	22.6	14.8	3.2	32.1	21.6		
waste (skin)	88.9	2.3	1.2	0.5	2.8	4.3		
whole	94.3	0.9	0.4	0.5	0.6	3.3	.012	.033
puree		1.8	0.5			7.2	.014	.035

DAIRY AND POULTRY PRODUCTS

Name	Moisture	Protein	Fat	Ash	Fiber	N.F.E.	Ca	P
Buttermilk								
condensed	70.1	11.3	1.6	3.7	—	13.3	.56	.33
dried	5.5	34.3	7.0	9.4	0.3	43.5	1.56	1.05
liquid	91.0	3.0	0.5	0.7	—	4.8	.18	.10
Eggs, whites	87.0	12.0		0.6		0.4	.012	.014
whole	75.1	13.4	10.5	1.0			.059	.166
whole	73.4	13.4	12.2	0.7		0.3		
yolks (fresh)	48.8	16.0	34.0	1.0		0.2	.147	.586
Milk, dried skim	4.7	35.8	1.0	8.8	0.1	49.6	1.27	.96
	4.7-8.0	31.9-35.7	0.3-1.9	7.2-8.4	(48.5-54.0)*			
skimmed	91.1	3.4	0.2	0.8	(4.5)*		.13	.11
skimmed	90.4	3.4	0.3	0.8	(5.1)*			
whole, cow	87.4	3.2	3.7	0.7	(5.0)*		.123	.088
whole, cow	87.1	3.6	3.7	0.7	(4.9)*			
Poultry By-Products								
cooked and dried	9.0	56.0	15.0	14.0				
Whey, condensed	42.7	8.8	0.6	5.9	0	42.0	.527	.487
dried	6.7	12.8	0.6	10.1	0.2	69.6	.83	.70
liquid	93.8	0.6	0.1	0.4	0	5.1	.05	.04

* Indicates a figure for total carbohydrates (i.e., N.F.E. plus fiber)

Photo, courtesy of National Fur News. Fox from John MacNeill's Mt. Evans Fur Farm, Golden, Colorado.

IV. SPECIAL CONSIDERATIONS OF FOXES

A. INTRODUCTION

In the wild, foxes are largely carnivorous (flesh-eating), although it is a matter of record that they also consume plant materials, including fruits and berries, and in addition have been known to eat insects. When a fox kills a smaller animal in the wild, it will consume the entire carcass, thus providing itself with a source of animal protein from the skeleton of the victim and the adhering flesh. It will also get some fat from the carcass and a small amount of carbohydrate from the contents of the digestive tract. This indicates in itself that the fox apparently requires a diet which has some variety. In the earlier days of ranch-raised foxes, most of the rations used were worked out by the old trial-and-error method, and during the course of time, reasonably satisfactory mixtures have been formulated. The actual amount of scientific information available is relatively small, which means that there is still a great deal of work to be done before the optimum requirements for the fox during various seasons of the year can be determined. This applies to all of the essential components of the diet—proteins, fats, carbohydrates, minerals and vitamins.

The tremendous variety of rations in use at the present time is but proof of the wide adaptability of these animals. There was a time when every rancher had his "secret formula", but in more recent years there has tended to be a general pooling of information about feeds and feeding methods. This has brought to light some things which were actually of great value and has served to eliminate some factors which were definitely deleterious.

B. RATION VARIATIONS

Most of the experiments which have been carried out have been with small numbers of animals over short periods of time and with not too many controls. However, this type of information is valuable and does give us some clues. Some of these rations have been used with foxes at various times of the year, and some proved to be useful without any modifications at any season. Others apparently were successful at certain times of the year but failed during other seasons. Thus, there is a limited amount of information available which tends to indicate that if the diet is nutritionally complete and well-balanced, there need be only very slight modifications from one season of the year to another. However, it seems agreed among most fox ranchers that there should be seasonal variations in the composition of the ration.

In the spring when the vixen is nursing her litter, she needs a wide variety of ingredients and also a large amount of food of high digestibility. During the summer adult animals perhaps require little more than a maintenance ration, though it must be remembered that this should be a balanced diet, and it should contain all of the known dietary essentials in the proper amounts and ratios to one another.

During the period when these adult animals are just being maintained on the ranch, there are also growing pups on the ranch. Rations for these should supply a variety of nutrients of high digestibility and good quality, to ensure rapid and satisfactory growth. It must always be remembered, though, that there is a constant danger of actually overfeeding animals by trying to push through them more food than their digestive tracts are capable of handling. Here, the "art" of feeding becomes the task of the feeder. There is a big difference between the rancher who has a complete and balanced diet and feeds it properly, and the rancher who has the same diet but feeds it unwisely.

During the autumn months it is desirable to have the foxes put on more weight and "finish" and, for this reason, most ranchers advocate a suitable adjustment in the diet. Then again for the breeding season, it is very necessary to avoid overfeeding, since breeding animals tend to become lazy when overly fat. The individual experience of the rancher and the knowledge of his own animals

are the best guides we have at the moment to the actual amounts of feed which should be given to any individual animal at this time of the year.

C. PROTEINS

Some estimates of the amounts of protein required by foxes during the various seasons of the year have been made. Of course, it is assumed that the feed provided is completely utilized, and in order to make allowance for losses during digestion and for the quality of the protein, the figures given in the following table do not necessarily represent the absolute minimum protein requirements, but rather a figure for use in calculating rations:

Estimated Daily Protein Allowance for 100 Foxes

Summer — June 1 through August 31	Small foxes..... 6.25 lbs.	Large foxes..... 9.40 lbs.
Early Fall — September 1 through October 15	Small foxes..... 7.80 lbs.	Large foxes..... 11.70 lbs.
Late Fall — October 16 through December 31	Small foxes..... 8.60 lbs.	Large foxes..... 14.00 lbs.
Winter and Spring — January 1 through May 31	Small foxes..... 9.00 lbs.	Large foxes..... 15.00 lbs.

In order to illustrate how this information may be of value, the following example is presented to show how calculations of the protein content of a given ration may be used to evaluate the adequacy of such a diet with reference to total protein content. Similar calculations may also be made for other individual diet components (i. e., fat, ash, etc.)

If it is assumed that a ration has the following composition, it will provide protein in accordance with the calculations shown:

Ingredient	*Pounds Used*	*Per cent Protein*	*Calculations*	*Pounds Protein*
Horse meat	40.0	18.0	40 x .18	7.20
Horse viscera	10.0	16.0	10 x .16	1.60
Sheep liver	5.0	20.2	5 x .202	1.01
Ground green bone	5.0	19.2	5 x .192	0.96
Commercial cereal	33.5	13.0	33.5 x .13	4.36
Vegetables (raw carrots)	5.0	1.1	5 x .011	0.06
Brewers yeast	1.0	48.5	1 x .485	0.49
Cod liver oil	0.5	—	—	—
Totals	100.0			15.68

Thus, 100 pounds of these ingredients, in the above proportions, will supply approximately 15.5 pounds of protein. From the table given above, it is seen that 100 large foxes require amounts of protein varying from between 9.40 and 15.00 lbs. It is therefore evident that 100 pounds of the above diet would provide the protein required for 100 foxes at the season when most protein is needed. At other

seasons, it would provide amounts considerably in excess of requirements, and therefore could be modified to include certain items containing less protein.

It should be noted that the above diet does not include any water used to bring the diet to the proper consistency for feeding. This is done intentionally, since all ration calculations should be made on the so-called "dry-basis" of ingredients as used and not on the "as fed" basis including the water, since various ranchers may like to feed this diet at different consistencies. If such calculations were made on the moist or "as fed" basis, these would have to take into account the amount of water used. By making calculations on the dry basis as used, there is a common basis for all calculations it is desired to make.

It is considered that the feeding of high levels of protein during the summer and fall is not advisable because such rations lead to an over-development of underfur at too early a date with the result that guard hair structure is sacrificed. The guard hair then tends to become open and streaky, it will rub off too easily and also will have a definite tendency to go off color before the pelt becomes prime. On the other hand, if the amount of protein is held at a lower level during the summer and early part of the fall, the development of underfur is delayed and the guard hair is given preferential treatment. Then, after the guard hair has reached fuller development, perhaps about the middle of October, an increase in the protein content of the diet results in a rapid and favorable development of the underfur, giving it depth and good volume. It has been estimated that the underfur comprises about 90 per cent of the total weight of the fur on a fox, therefore, the feeding of high protein diets should be withheld until this dense growth is desired.

Some years ago, a survey was made of a large number of fox farms in Canada in an attempt to determine the most desirable percentage of meat in the diet at various times of the year. In summary, meat usage varied from 30 to 65 per cent or more of the diet in the summer and from somewhat less than 70 to more than 75 per cent in winter. When correlated with reproductive performance on the various ranches, it was observed that those ranches which used the most meat at all times of the year showed a higher production of pups per female. Other general observations made in this survey indicated that the feeding of fish as part of the protein had no effect on the reproductive performance. The same was also true of the utilization of milk, either whole or skim.

In contrast to the above, one other series of experiments should be mentioned at this point. In these trials, a ranch was divided in the spring into three groups. Group I was fed a diet containing a high percentage of meat, wherein the meat bore a ratio of 3 to 1 to other ingredients. In Group II this ratio was 2 to 1, and in Group III, the ratio was 1 to 1. The males in Group I had insuf-

ficient sperm until late in the season so there was no time for re-mating. It was also noted that females on this diet came into heat later than normally. There was a large number of fatalities at birth in the case of those animals fed the highest level of meat. Reliable re-breeders lost their litters and the young appeared to be crushed at birth. Using high levels of meat, less than 20 per cent of the females had litters of 5 or more, while with low levels of meat, 66 per cent of the litters were 5, 6, 7 or 8 in number. It was observed that those foxes receiving high levels of meat were more susceptible to worm infestation, showed decreased width of the silver bar in the fur, and the silver was dull and dirty in appearance. Those receiving high meat levels looked like good animals until some time in September, but from then on, the pelts rapidly deteriorated in appearance. This was not noted in those foxes receiving low levels of meat. These latter also showed a clear silvering of the pelt and less susceptibility to worms. Such evidence as this would tend to indicate that lower levels of meat in the summer and early fall are preferable as far as fur production is concerned. It also appears from this work that high levels of meat are deleterious to reproduction.

The statement has been made many times that research work should be undertaken to establish the amino acid composition of the protein which comprises the underfur and guard hair of the fox. At some time in the future this information may become available and then we shall have a better understanding of those amino acids which should be included in the fox ration. As has already been pointed out in the section on protein under "Feed Components", the fox has definite requirements for the various amino acids—though they are unknown at the present time— and so when we have learned these amino acid requirements, we will probably be able to feed more accurately those individual amino acids which are required at certain times of the year in greater quantities. If, for example, the fox required the sulfur-bearing amino acids for the building of good underfur and guard hair, perhaps rich sources of these amino acids could be eliminated from the diet during certain periods of the year. Then we should start feeding diets rich in them at a suitable time before the furring season actually begins.

It must always be borne in mind that proteins from various sources differ in their amino acid composition. It is for this reason that one pound of meat (lean muscle) will have a different biological value for the fox than one pound of cereal, assuming that both have the same total crude protein analysis. In general, the proteins of milk and eggs have very high biological value, followed closely by the proteins of the glandular meats, which are of higher biological value than those of the muscle meats. These latter are, in turn, of higher biological value than the proteins of connective tissues, sinews and the like.

Plant and cereal proteins may be deficient in one or more of the essential amino acids. Since this is true, these materials cannot be

expected to meet the requirements of the fox when they are fed alone. Generally speaking, meat and cereal items can be chosen for the diet which will have a complementary action towards one another. By this it is meant that the amino acid deficiencies of one are made up for by the inclusion of the other. This is a fundamental procedure in providing an adequate balance of amino acids for the fox or any other animal. Hence, it is impractical to state a definite protein requirement—or amino acid requirement—for any special season of the year, or for any special function of the body, except in terms of specific food proteins or combinations of proteins and, therefore, of amino acids.

In a series of experiments reported some six years ago, a study was made of the digestibility of certain proteins by foxes. The proteins of blood meal, linseed oil meal, meat scraps and soybean oil meal were all digested to a lesser extent than was the protein of frozen horse meat. Of those mentioned above, meat scraps and soybean oil meal were more readily digested than blood meal or linseed oil meal. The work also demonstrated that the protein of liver meal and fish meal was not significantly different in digestibility from the protein of frozen horse meat. From the standpoint of digestibility then, as possible substitutes for horse meat, the most worthy of consideration would be liver meal and fish meal and, to a more limited extent, meat scraps and soybean oil meal. The actual figures for percentage digestibility of the crude protein of these various ingredients are shown in the following table:

Ingredient	*Approximate Digestibility of Crude Protein (%)*
Horse meat	*91.0*
Meat scraps	*85.8*
Fish meal	*88.0*
Liver meal	*87.9*
Blood meal	*77.7*
Soybean meal	*85.8*
Linseed meal	*80.8*
Homogenized condensed fish	*95.0*

Another thing must also be recalled about proteins. They can serve as sources of energy for the fox, although as a general rule they are not considered as important energy providers.

It is important to recall that items included in the diet largely as sources of available protein may also have other important attributes, such as their content of essential minerals and vitamins. In some instances, the mineral and vitamin content of cereal grains is lower than that of meats and the glandular tissues. This is probably one good reason why the substitution of meat cannot be carried to an extreme, since the supply of some essential nutrients may be decreased to a considerable extent unless the cereal used is properly fortified.

The control, or basal ration, in which this meat substitution was tested, contained the following ingredients:

Horse meat	30 per cent
Steamed bone meal	2 per cent
Liver (fresh)	5 per cent
Cooked fish	10 per cent
Visceral meats (horse and beef spleens)	13 per cent
Vegetables (carrots and tomatoes)	5 per cent
Dried brewers yeast	1 per cent
Cod liver oil	0.5 per cent
Cereal mixture	33.5 per cent

The above basal ration was first tested for palatability with a few experimental animals using the offal mixtures substituted for horse meat at various levels and upon acceptance, the various groups were placed on experiment. The results of this latter trial follow. The substitution of offal mixture was made at the expense of the sum of horse meat, cooked fish and visceral meats. Note that the 5 per cent of fresh liver was left in the diet.

One group of foxes (2 males and 2 females) was maintained on the basal ranch diet as a control. The second group (2 males and 2 females) was placed on a diet wherein two-thirds of the content of meat, cooked fish and visceral meats was replaced by the offal mixture given above. In the ration of a third group (2 males and 2 females) all of the normal content of horse meat, cooked fish and visceral meats was replaced. In all groups, the foxes were maintained in individual raised pens with mesh floors located in a shed. The trials were begun on June 12 and continued through November 27. Some of the animals were carried through the succeeding breeding season on the same rations and gave indications that reproduction and lactation performance were normal, though it must be borne in mind that the number of animals involved was very small.

The foxes were weighed at intervals of three weeks during the experimental period. Table II presents a summary of the weight gains during this time as an indication of the growth of the animals:

TABLE II

	Weight (lbs) 6/12		*Weight (lbs) 11/27*		*Weight (lbs) gained 6/12 to 11/27*	
	Males	*Females*	*Males*	*Females*	*Males*	*Females*
Basal ration	4.80	4.85	12.30	9.50	7.50	4.65
2/3 replacement	5.65	4.45	14.00	9.95	8.35	5.50
100% replacement	5.05	4.50	12.45	10.05	7.40	5.55

The results obtained with the experimental diets were slightly superior to those with the control ration. At the time of pelt grading, no significant differences were noted among any of the animals. Three foxes in the group with two-thirds of the horse meat replaced by offal mixture were reported as in fat condition, while two on the regular diet were reported as being slightly thin. The results of

such trials as this are very encouraging and give the rancher a possible method of reducing costs without sacrificing diet or pelt quality.

Analysis of fecal materials from these animals indicated that there was only a very small amount of waste in the rations containing no lean horse meat, since digestibility trials showed a total digestibility of 93.4 per cent for the diet with two-thirds of the horse meat replaced and 93.1 per cent of the ration with all of the horse meat replaced and also 93.1 per cent for the control or basal diet. These differences are too small to be considered significant.

The two females in each group were mated with males from the same group and gave the following production during the following year:

Basal ration	*2 females produced 9 pups*
2/3 replacement	*2 females produced 10 pups*
100% replacement	*2 females produced 10 pups*

These females were maintained on their respective rations all during the winter and spring. The pups born were successfully carried through the period of lactation and grew at a normal rate. From the original males and females and the pups produced by them, a total of 24 males and 14 females were carried through the entire year and on through the next breeding season with continued excellent results. This is an indication that a nutritional deficiency did not exist in the ration as a whole and that the foxes continued to utilize the offal products as a source of dietary protein with good efficiency.

Later during the second year of the trial it was found necessary to modify the offal mixture to some extent, the change being the replacement of part of the calf heads with telang livers. The calf heads were reduced to 10 parts of the offal mixture and 5 parts, by weight, of telang livers were added. Because of this, the amount of fresh liver in the basal ration was reduced correspondingly. Results continued to be satisfactory.

LIVER FEEDING

The name "telang liver" is applied to certain livers from the packing house which are characterized by an enlargement of the terminal blood capillaries—a condition known as Telangiectasis. Samples taken from various sources throughout the country have been studied extensively and it was found that these livers showed no evidence of inflammation or infection, but there was a dilation of the central veins of the liver which causes an atrophy of the adjoining tissue. These livers have come into wide usage in both fox and mink diets in certain areas. Inasmuch as they are condemned for human consumption, they are dyed green. They have also been investigated as sources of certain of the B-complex vitamins and in all cases have been found to be on a par with normal livers. An interesting study has revealed that the vitamin A content of these livers is generally

in excess of that of normal livers. As a result of all this work, it has been adequately demonstrated that telang livers are as good for fur-bearing animals as are normal livers. Recent work has also demonstrated that these livers are generally found in well-fed animals and, therefore, should be very nutritious. It is the contention of some that the condition is not one of disease at all, but bears a relationship to the previous feed of those cattle in which they occur.

Almost every good fox ration that has appeared in print in most of the fur journals is found to contain some fresh liver. The amounts used have ranged to as high as 15 per cent. Amounts in excess of this figure have not proven too successful in some rations because a laxative effect has resulted. If a rancher cannot obtain enough to make up 15 per cent of the dry weight of ingredients of the diet, he is well advised to use whatever is available up to this figure. In some isolated cases, 10 per cent has even proven laxative, and a more or less general level of 5-8 per cent has been adopted by ranchers. Fresh livers from horses and cattle are of equal value as far as is known. It may also be possible to purchase the so-called "telang livers" as already indicated. They may be used in the same manner as fresh liver would be used.

If fresh liver is not available, the rancher will be well advised to use the dehydrated liver as a substitute for the fresh product.

FISH FEEDING

CHASTEK PARALYSIS — THIAMINE DEFICIENCY

While possible protein sources for the fox ration are under consideration, there is no better time to mention fish feeding. For many years there has been considerable discussion, both pro and con, relative to the use of fresh or frozen fish in fox rations. Fish, as we all know, are a good source of certain valuable nutrients and yet it has come to light that there is a potential, if not actual, danger in feeding *raw* fish to fur-bearing animals. If fish could be safely used all the time, here is a partial answer to the question of expensive meat for fox and mink, since they are relatively cheap, contain protein of good quality and are highly digestible and nutritious. Both nutritionally and economically, therefore, this problem has been a most fascinating one. Because of this, it has demanded the attention of scientific research.

A disease condition, due to the feeding of raw fish, was apparently first observed in 1932 and was referred to as "Chastek Paralysis" since the original contact with it was on the fur farm of Mr. J. S. Chastek at Glencoe, Minnesota. This name was applied to the condition by the late Dr. R. G. Green, and the name has remained. As he first reported it, the disease resulted from the feeding

of raw, frozen fish. It was not associated with spoilage, for in all cases the fish were frozen immediately after netting and were thawed out only at the time of feeding. This disease usually appeared on ranches about one month after the feeding of raw fish was begun.

Different varieties of fish from both fresh and salt water have been observed to produce the disease. Carp from the fresh-water

Photo, courtesy of National Fur News. Fox pup from August H. Genetti's Fur Ranch, Sugarloaf, Pennsylvania.

lakes of Idaho and Wisconsin, mullets and suckers from Wisconsin and Minnesota as well as smelt from Wisconsin lakes, and even ocean whiting from the Atlantic coast have been implicated.

The disease, developing on a ranch, does not usually appear in a large number of animals at once, as in the case of a food poisoning, but involves a relatively small number of animals daily, much in the nature of a directly spreading epizootic disease. It was early demonstrated, however, that it is not transmissible from one animal to another and an extended series of epidemiological studies bore this out. Moreover, in all cases, the disease has stopped almost immediately when the feeding of raw fish was discontinued.

Loss of appetite ushers in the actual condition and usually occurs simultaneously in pens distant from one another. After several days when the animals show lack of appetite, a spastic paralysis slowly develops, often taking several days to reach a maximum. At the onset of the paralysis, the fox runs with short, stiff jumps, rather than with the easy, graceful gait usually seen. A desire to sit still and lie down becomes apparent. As the paralysis progresses, the movements of the animals stiffen and in-coordination is an actuality. Often, the animal performs very unusual movements apparently because certain muscle groups are spastic while others are still controllable. Upon sudden disturbance, the victims have been known to jump high in the air and fall on their backs. In spite of this, the fox will remain completely conscious and alert. If death does not occur at some early stage, the paralysis gradually envelopes the entire body and the animal becomes stiff and lies with the head drawn far back. Almost all of the voluntary muscles are involved ultimately, though the involuntary muscles may still function normally.

Unless there is some relief, the animal gradually sinks into a coma and death generally occurs in from one to four days after the onset. It is not known just what the ultimate mortality would be, since, when the trouble is first encountered, the feeding of fish is discontinued. It is safe to say that mortality may run to 35 or 40 per cent of those animals exhibiting symptoms.

During the early part of 1937, the condition was first produced experimentally by Green and co-workers in two groups of foxes by feeding a diet containing 50 per cent raw fish. In one group of 64 foxes, eight died of Chastek Paralysis during a period of 26 days. The disease was again reported in five major outbreaks by the end of 1937. It was observed to be most common during the first three months of the year, presumably because the winter diet had been borderline in some factor. It was about this time that the deficiency status was given to this disease. Dr. Green and his group ascribed Chastek Paralysis to a deficiency of vitamin B, and it was later adequately demonstrated that the true trouble was a deficiency of vitamin B_1 (thiamine).

When examinations were made at autopsy, there was revealed a massive degeneration of the liver and a variable degree of degeneration of the heart muscle. There were also hemorrhages which could be observed grossly in the brain. Lesions identical with those found in the brains of foxes have been also described in the brains of dogs suffering from a deficiency of thiamine.

Thus, it appeared at that time that the action of certain types of raw fish was to induce a deficiency of vitamin B1. This appeared to be a virtual impossibility since it seemed unreasonable that a standard food ingredient could cause such devastating results.

The basic clue for the answer to this problem came from the finding of certain cases of paralysis where there was no fish in the diet. An analysis of these cases showed that the diet used was borderline in its content of thiamine and it was, therefore, postulated that the addition of raw fish—which are naturally low in thiamine content—merely diluted the small amount already present and thus made the diet sub-optimal with regard to this factor. It was likewise postulated that the feeding of raw fish in some manner increased the requirement of the fox for this vitamin.

However, there was a fault in both of these lines of reasoning, in that the feeding of cooked fish was entirely without serious effects. Some took the attitude that the feeding of cooked fish lessened the necessity for thiamine in the diet so that rations which were unsatisfactory when including raw fish would be all right when they contained cooked fish.

During the early part of 1939, after another series of disastrous outbreaks of Chastek Paralysis during 1938, the light began to dawn. It was not definite just which of the then-known members of the vitamin B complex was at fault, so the recommendation was made that the disease be treated, for the time being, as a deficiency of this entire group of vitamins. During these early months of 1939, Carlstrom and Jonsson, in Sweden, reported curing a disease which appeared to be identical with Chastek Paralysis by the injection of crystalline vitamin B1. They also stated that the disease had been produced experimentally and was prevented by the feeding of yeast.

The similarity of the pathological changes noted in foxes and in other animals showed that the deficiency of vitamin B1 was the true cause of the paralysis. This much having been determined, the problem was to explain how the feeding of raw fish could cause a thiamine deficiency.

Suffice it to say that evidence was presented, during 1941, by Spitzer et al at the University of Wisconsin, which indicated that the observations previously made with foxes had been confirmed in the animal laboratory with chickens. It was also shown that the condition could be reproduced in foxes which had recovered from a previous

attack. After a series of laboratory tests, the conclusion was reached that the actual inactivation of thiamine (vitamin B_1) was possible and that this could occur in the feed mixture itself, even before the animals consumed the feed. The extent to which inactivation occurs is a function of the period of time the fish is in contact with the rest of the feed ingredients. It was postulated at that time that the reaction might be enzymatic in nature. More recent work has demonstrated that there is a factor in certain species of raw fish, an enzyme which has been given the name "thiaminase", which is capable of inactivating thiamine. This factor is destroyed by heating and, in virtue of this fact, we have an explanation as to why cooking of fish renders them safe for consumption by fur animals. The destructive factor itself is destroyed in the cooking process.

That this thiamine-inactivating factor is very potent can be readily understood when, on the basis of calculations given by Green, one pound of carp is able to inactivate 15 milligrams of thiamine. Calculations from unpublished data of the Wisconsin group indicated that one pound of raw carp could inactivate somewhere between 9 and 11 milligrams of thiamine. Considering the state of development of assay methods at the time this work was done, this agreement is considered excellent.

Now just what does all this mean to the fox—and mink—rancher today? Simply this: fish are excellent food for both foxes and mink, but be sure they are cooked before using. If one rancher does not have suitable facilities for cooking, the raw fish may be fed on alternate days making sure that the ration contains additional amounts of thiamine from such sources as brewers yeast on those days when fish are omitted. Another variant of this is to feed a diet containing raw fish for two or three consecutive days, followed by a two- or three-day period when no fish are fed, then revert to the raw fish feeding again for two or three days, and so on. Either of these systems may be used. A more recent development in using fish involves the feeding of homogenized condensed fish, a product which has recently become available in plentiful supply. Since homogenized condensed fish has been subjected to heat in the course of processing, there is no danger of encountering Chastek Paralysis when it is used.

D. FATS

There is very little information in the literature of fur farming which relates specifically to the amount of fat which is required by foxes. A survey of the composition of many diets which have been published, and calculations made from them, indicate that the fat content of the average fox ration varies widely—between about 2 and 7 per cent. This figure is on a dry-matter basis. By this is meant, it is calculated on a moisture-free basis. Inasmuch as the average fox ration may contain between 70 and 75 per cent moisture,

as fed, this means that the fat content, as the ration is fed to the animals, is about 25 per cent of the figures given above, i.e., between 0.5 and 1.75 per cent.

Most of the commercial cereal mixtures on the market will contain between 2.5 and 5.0 per cent fat on the dry basis, which means that when water is added to them for feeding, the fat percentage in the diet when fed will be about the same range as given above.

It is important to recall that the presence of some fat in the diet is an aid to proper absorption and utilization of the fat-soluble vitamins, principally A and D, and it should also be remembered that certain components of fat (the so-called essential unsaturated fatty acids) are very important in nutrition for the promotion of growth and prevention of skin diseases. The significance of these essential unsaturated fatty acids in fur-animal nutrition has not been worked out. Inasmuch as the usual fox ration contains fats from a variety of sources, there is little likelihood of a fat deficiency showing up.

E. CARBOHYDRATES

The situation with respect to the carbohydrate portion of the ration is just about in the same position as that of fat. There are few available data to indicate what the carbohydrate analysis of a fox feed should be, let alone what is the proper ratio between the two components of the carbohydrate portion—nitrogen free extract and crude fiber.

The range of cereal components in the fox ration varies tremendously; in fact, it may comprise anywhere between 25 and 60 per cent of the diet. Generally speaking, however, the average range is from 25 to 40 per cent.

Among the common cereals in use are products from corn, wheat, rice, oats and barley, as well as certain amounts of these grains themselves. In addition, such other products as soybean oil meal and milk by-products will be found as common ingredients.

The total caloric requirement for maintenance of mature foxes has been given by some authorities as 95 to 100 calories per kilogram (2.2 pounds) of live weight, or about 45 calories per pound. Some more recent determinations indicate that the requirement of calories per pound of body weight per day is in the range of 50 to 55, slightly higher than the earlier figures. This may be interpreted to mean that as the animal grows larger and increases in weight, the caloric requirement will also increase. The figures given above are those purely for maintenance and we must add to them an increment to cover the special requirements during certain times of the year. These periods would include growth of pups, pregnancy and lactation.

There has always been a question among fox ranchers and scientific personnel as to whether the cereals in a fox diet need to be cooked. Certain experiments with limited numbers of animals have indicated very little difference between rations containing raw and cooked cereals, while others have shown a decided advantage in favor of cooked cereals. If grains are fed raw, they should be ground as finely as possible. This will assist the animals in digesting them more efficiently. Cooking of cereals will increase their digestibility, however, and it is for this reason that the use of commercially processed cereals of uniform quality has become common practice in recent years, replacing to a large extent cereal feeds made from raw ingredients. Reliable feed manufacturers have made very extensive investigations of the proper cooking procedure for the various cereals, and, therefore, products from such houses are eminently satisfactory.

Another very important benefit to the rancher in the use of commercial, cooked cereal preparations is that he can feel certain of the continued high quality of material from one batch to the next. This is an important consideration. Then, too, the use of commercial cooked cereal is probably cheaper in the long run, because no special grinding and mixing is involved and the cereal products can be stored conveniently in a cool, dry place without special attention. Behind a reliable commercial cereal stands also the guarantee of the manufacturer as to its contents and wholesomeness.

F. VITAMINS

So far, little indication has been given of anything resembling an accurate figure for the minimum requirement of the fox for any of the basic feed ingredients—proteins, fats and carbohydrates. When we come to a consideration of the vitamin requirements of the fox, the problem is still more perplexing. The specific requirement of the fox for any of the vitamins has not been accurately determined, so any figures that can be presented, with the possible exception of those for vitamin A, would have to be drawn from analogy with the figures which have been published for such an animal as the dog. Many have considered this as a fair risk, since the fox and dog are somewhat related.

1. VITAMIN A STUDIES

The daily vitamin A requirement of the dog has been placed between the rather wide limits of 10 and 360 U.S.P. (United States Pharmacopoeia) units per pound of body weight per day. It has been claimed that fox pups definitely require vitamin A, though only recently has there been any scientific proof for it. Such information about vitamin A requirements is highly desirable, since it is another important link in the chain leading to complete nutrition.

Vitamin A has found a place in all dietary regimens for laboratory and domesticated animals, and it is therefore assumed that its role would be similar in the case of the fox, since it has functions in promoting growth, in reproduction and in general health and well-being. An investigation was undertaken by Holmes, Tripp and Satterfield, some years ago, of the vitamin A content of the livers of pups and mature silver foxes in comparison with the data obtained for wild red and grey foxes. The foxes from the wild were found to have large liver stores of vitamin A, while the ranch-raised foxes were shown to have much smaller stores. There was no apparent relationship between the vitamin A content of the liver and the quality of the pelt, among other things. The finding of large amounts of vitamin A in the livers of foxes from the wild is by no means proof that the vitamin A liver reserves of the ranch-raised animal need to be that high. The only suggestion would be that the lower content observed in the case of ranch-raised foxes might tend to be borderline. It is probable that the requirements of the vixen during pregnancy and lactation are considerably higher than for the adult, and the same might well be true of the growing pup.

The vitamin A-deficiency state in the fox was found to be characterized by a cocking of the head, followed by periods of incoordination of movement, periods when the fox would exhibit whirling movements, and there were widespread changes in the tissues of the bronchi, kidneys, pelvis, urinary bladder and vagina. In some instances, the deficiency progressed to the point of coma and some of the animals also showed xerophthalmia.

In the course of these studies, it was determined that the minimum amount of vitamin A necessary to prevent the deficiency symptoms in growing fox pups lay somewhere between 15 and 25 I.U. (International Units) per kilogram (2.2 pounds) of body weight per day. However, there was no significant storage of vitamin A in the livers of foxes until the diet provided 50 to 100 I.U. of vitamin A per day. The skins of these animals were all normal in appearance when pelted.

As has been suggested previously by many workers, vitamin A deficiency is a possible cause of urinary calculi in foxes. In work reported by Bassett and co-workers, severe depletion of vitamin A was definitely associated with the occurrence of urinary calculi. The incidence of calculi was inversely related to the amounts of vitamin A fed. By this is meant that when the diet contained more vitamin A there was lowered incidence of calculi, and vice versa. No calculi were observed in these foxes when the diet provided 100 I.U. of vitamin A for every 2.2 pounds of body weight per day. However, the pelts of these animals were lacking in underfur, were badly off color and many still showed remains of puppy fur. Pelts of those foxes which received more vitamin A were more nearly normal than those receiving smaller amounts.

Further experiments were conducted by Bassett and co-workers to make a study of the utilization of carotene as a source of vitamin A for the fox. These experiments showed that the fox can utilize carotene as a source of vitamin A, which appears reasonable in view of the fact that certain experiments have demonstrated that the dog, a closely related species, can utilize carotene as a source of vitamin A. The utilization of carotene, however, was not as efficient as that of vitamin A itself.

The practical consideration, of course, is just how much vitamin A need be fed to foxes each day. It is necessary to feed enough to prevent the occurrence of symptoms of vitamin A deficiency, and there should also be sufficient so that there will be a satisfactory level in the circulating blood, plus an allowance for some storage in the liver.

On the basis of these more recent experiments, it appears that at least 50 I.U. of vitamin A are required daily for each pound of body weight of the fox. Levels of 100 and 300 I.U. per pound of body weight per day were also satisfactory and were not found to be above the level of physiological efficiency. Therefore, until further data are available, it is recommended that the fox diet should provide somewhere between 50 and 300 I.U. of vitamin A as such for each pound of body weight each day. If carotene is used as the source of vitamin A, and since its utilization is not as efficient as that of vitamin A itself, the higher level of 300 I.U. is recommended.

For various body weights of foxes, therefore, we might construct a table indicating the actual amounts of vitamin A necessary. Such a table is as follows:

Body weight (pounds)	*Units of vitamin A required per day**
1	300
2	600
3	900
4	1200
5	1500
6	1800
7	2100
8	2400
9	2700
10	3000

* The above table is based on the upper limit of 300 I.U. per pound of body weight indicated above.

2. VITAMIN D STUDIES

Any disturbances in the normal metabolism of an animal which lead to improper and defective calcification of growing bones come under the very general classification of "rickets". At the present time, clear-cut cases of rickets are seldom, if ever, found. Undoubtedly, this is due to improvements in the nutritive value of the rations

used and to an advanced knowledge of nutritional requirements, better environmental conditions permitting access to adequate sunlight, especially during the growing period in late spring and early summer, and to the wide usage of such vitamin D sources as cod liver oil, irradiated yeast and homogenized condensed fish.

Since foxes are usually supplied with vitamin D either from the sunlight or concentrates in the ration, the problem of rickets in foxes due to a deficiency of vitamin D is of no great significance.

However, because of the fairly common practice of fortifying the diet with minerals, it is quite possible that ill-chosen mineral supplements may produce an improper ratio of calcium to phosphorus in the diet, leading to the occurrence of rickets.

The active vitamin D which is formed in the skin, feathers or furs of animals on exposure to sunlight, is absorbed into the blood while that which is ingested with the food is absorbed directly from the intestinal tract, if adequate amounts of bile salts are also present.

Apparently, the animal body is able to conserve its stores of vitamin D, since it is known that the administration of small doses will have an effect lasting over a period of several weeks. Larger doses are stored for a longer time.

The exact means by which vitamin D functions in the metabolism of calcium and phosphorus is not yet fully known. It appears, however, that the vitamin is mainly concerned with absorption of these elements from the intestinal tract.

It has been reported by Hansen that "in foxes, the symptoms of rickets are limited chiefly to deformities of the bones. Occasionally, weakness and nervous symptoms such as paralysis, spasms and even convulsions are encountered. As a general rule, the evidence of this disease in foxes is limited more to the bones of the forelegs than to any other place in the body. In the affected pups, the front legs become enlarged at the joints, thickened and crooked. As a result of their bowed condition, they appear considerably shorter than normal."

As already indicated, the best sources of vitamin D for fox feeding are properly fortified cereal feeds, cod liver oil and homogenized condensed fish.

3. VITAMIN B COMPLEX STUDIES

Up until about a year ago, the literature of fox nutrition was virtually devoid of papers dealing with studies of the requirements of the fox for various members of the water-soluble B group of vitamins. During 1940, a paper appeared from the University of California at Berkeley, dealing with the anti-grey hair vitamin and its importance in fox nutrition, but it was not again until 1947 that several papers

Photo, courtesy of National Fur News. Fox pup from Dr. M. R. Howard, Genesee Mountain Fox and Mink Farms, Golden, Colorado.

appeared from the University of Wisconsin, and there was evidence of renewed interest in this important phase of fox nutrition.

For the sake of convenience, the various vitamins, exclusive of thiamine (vitamin B 1), will be considered individually. No mention need be made of thiamine at this point since its importance in fox nutrition has already been dealt with in the section on fish feeding.

Studies of this group of vitamins have been rendered more simple in the animal laboratory through the development of the so-called "purified diet." The development of such a diet has been a long drawn out procedure. In preparing such a ration, one must provide virtually vitamin-free sources of materials which will supply proteins, fats and energy. Generally, the protein is derived from a specially treated casein, made from milk, during the course of whose purification traces of B vitamins and other impurities have been most carefully removed. The source of fat is usually a highly refined edible oil like corn oil or cottonseed oil, and the energy is provided through the use of pure sugar. To such a "basal diet" then, one can

add known amounts of all those vitamins which are available in chemically pure, synthetic form, plus purified sources of still others, such as cod liver oil, and a source of minerals and then have a "synthetic" or purified diet. Such a diet is most useful as a tool in any attempt to study unknown factors or to determine the requirements of a laboratory animal for any of the known factors.

The procedure is to make the diet complete in all of the known nutritional factors with the exception of that one which is under study. This latter factor can then be added in known, graded amounts and it is thus possible to determine the point at which the animal no longer shows a deficiency.

A typical, synthetic diet for this type of work is about as follows:

Sucrose	66 per cent
Vitamin-free casein	19 per cent
Cottonseed oil	8 per cent
Cod liver oil	3 per cent
Salt mixture	4 per cent

To make this basal diet complete, insofar as possible, certain amounts of other vitamins must be added. Most of these are available in crystalline form and are added in the amounts shown below:

Vitamin added	*Amount per 100 grams of diet*
Thiamine	200 micrograms
Pyridoxine	200 micrograms
Riboflavin	400 micrograms
Calcium pantothenate	1.5 milligrams
Niacin	4.0 milligrams
Choline	100 milligrams
Folic acid	100 micrograms
Biotin	50 micrograms

Still, our test diet is not complete. We must also add some other factors, as follows:

Vitamin added	*Amount fed per day*
Inositol	20 milligrams
para-Aminobenzoic acid	50 milligrams
alpha-Tocopherol	2 milligrams
Vitamin K	0.5 milligrams

Such a combination as this will produce good growth in the laboratory animal. Although some of the names in the above columns are unusual, they are mentioned here because sooner or later they will appear in the fur farming literature, and from this limited introduction it is hoped that the rancher will have at least a speaking acquaintance with them.

By now, it is possible that the amounts of these various vitamins have become quite confusing. Because the amounts of various vitamins required by the laboratory animal are so small, the nutri-

tion worker uses a different scale of weights than most ranchers are accustomed to. The following tabulation may help give an insight into the meaning of such terms as "milligram" and "microgram".

1 pound is equal to approximately 454 grams
1 ounce is equal to approximately 28.5 grams
1000 grams is more commonly known as 1 kilogram and is roughly equivalent to 2.2 pounds
1 gram is equal to 1000 milligrams
1 milligram is equal to 1000 micrograms or gamma

In other words, when we speak of adding 50 milligrams of a certain vitamin to a diet, we are adding about seventeen ten-thousandths of an ounce. Further, if we are adding 50 micrograms of a vitamin, such as in the case of biotin above, we are adding about 0.0000017 of an ounce of the factor. These, as can readily be seen, are microscopic amounts. Despite this, the chemist or nutritionist can do it quite accurately!

With this background, let us see what the nutritionist is able to tell us about certain of these vitamins with reference to the nutrition of the fox.

A. RIBOFLAVIN

On the basal ration outlined above and supplemented with all of the known vitamins except riboflavin, foxes showed a definite decrease in rate of growth after as little as two weeks. A single, massive dose of riboflavin in one fox caused a prompt resumption of normal growth. Then, some three weeks later, there was a sudden failure in growth again, and the animal died. Two other foxes on the same diet, devoid of riboflavin, showed acute deficiency symptoms after three to four weeks; the characteristic symptoms were muscular weakness, convulsions and finally they lapsed into a coma. After administration of large doses of riboflavin, they were restored to consciousness and regained muscular control after as little as two hours. They then started to gain weight normally but the deficiency showed up again as soon as the limited body stores of this factor had become depleted. There was then noted a failure of growth, a cloudiness of the lens of the eyes and a lessening of production of pigment or color in the underfur and guard hair. The lack of proper pigmentation of the fur continued and, some time later, the guard hair and underfur were white. Similar symptoms have also been observed in dogs.

Riboflavin is most abundant in those organs of the dog where the most rapid changes are taking place, such as liver, heart and kidney, and in plants, it is largely in the leaves and embryos. It is also found, in more or less abundance, in many common food ingredients such as milk, eggs, muscle meats, fruits, whole grains and vegetables.

B. NIACIN

This factor is probably better known as nicotinic acid, niacinamide or the "pellagra-preventative" factor. When a severe deficiency of this factor was allowed to develop in foxes on the synthetic diet complete in all factors except niacin, it was observed that the foxes lost weight, failed to eat normally, showed severe inflammation of the gums, redness of the tongue and diarrhea. Similar symptoms have been observed in dogs suffering from nicotinic acid deficiency also. On the basis of single dose feedings of niacin, the requirement for this factor for growing pups was shown to vary widely—between 0.4 and 2.0 milligrams for each kilogram (2.2 pounds) of body weight per day.

Good sources of this factor, available for fox feeding, are meats, fish, yeast, meat scrap, enriched bread and whole grain cereals.

C. PYRIDOXINE

When foxes were placed on the synthetic diet minus only pyridoxine (also known as vitamin B_6), there was a loss of appetite and a cessation of growth after about five weeks. Later, the deficiency was repeated and the animals became listless, lost their appetites and became anemic. The requirement for pyridoxine was tentatively set at less than 0.2 milligrams for every 100 grams of ration fed daily.

Among good sources of this factor are egg yolk, wheat germ, yeast, liver, kidney, muscle meat, milk, legumes and whole grains.

D. PANTOTHENIC ACID

Up until about 1940, this factor was one of those ill-defined members of the vitamin B complex and was then referred to as the "filtrate factor." It was this vitamin which was investigated with foxes by the California group. They found that, on a purified diet supplemented with fish liver oil, wheat germ, riboflavin and nicotinic acid, one of their animals died after 26 days, but two others lost most of their fur after being on this deficient diet for only 44 days. The new fur which came in was light grey in color. A "filtrate factor" preparation fed to other foxes, together with the supplemented diet, permitted the foxes to retain their fur and have normal, dark silver pelts.

More recent experiments by the Wisconsin group showed that, after two or three weeks on a synthetic diet supplemented with all the known vitamins except pantothenic acid, there was a cessation in the growth of pups, in spite of the fact that their food consumption remained normal. Some of the animals died so suddenly that there was no opportunity to treat them. Some of these foxes were examined after death and showed fatty degeneration of the liver, gastro-

enteritis and a cloudy swelling and congestion of the kidneys. The deficiency symptoms, the dramatic response when doses of pantothenic acid could be administered, and the findings on examination of the dead animals are all quite similar to those which have been observed in dogs in the laboratory. Preliminary results indicate that the requirement for this vitamin for the growing fox is greater than 0.25 milligram per 100 grams of ration fed.

The best sources of this factor include egg yolk, liver, kidney, meat scrap, dried whey, yeast, milk, buttermilk, molasses, rice bran, lean meat and cereal grains. Lesser amounts are found in certain vegetables.

E. FOLIC ACID

Growth of fox pups receiving the purified diet complete in all respects except for folic acid was lessened, they lost weight and appetite and became anemic. Some of them died. Growth of fox pups fed the purified diet supplemented with folic acid for a period of 15 to 17 weeks compared quite favorably with that of pups fed a diet containing meat, cereals and vegetables.

Further information indicates, however, that both fox pups and adults receiving all of the known vitamins in crystalline form will still develop a deficiency. It has been found that the feeding of fresh liver results in a remission of the anemia and permits a rapid increase in body weight. This means that the story is not complete even yet and it suggests that fresh liver contains an additional factor (or factors), as yet unknown, which is necessary for the normal nutrition of the fox.

Good sources of folic acid include liver, yeast, cereal grains (wheat, malt sprouts, oats, corn, polished rice, rice bran, linseed meal, alfalfa meal and soybean meal), fish meal, grass juice, spinach, egg white and yolk, bone marrow, meat scraps, milk, powdered milk and whey.

4. ASCORBIC ACID (*Vitamin C*)

Scurvy, the result of inadequate intake of vitamin C has never been experimentally produced in silver foxes. Likewise, the deficiency state has not been produced in the dog and the evidence is that the latter animal synthesizes its own vitamin C. The same is assumed to be true for the fox. However, there have been reports of a condition which occurs spontaneously and has been referred to as "scurvy" and which is relieved by the administration of ascorbic acid. These symptoms are usually seen in young animals and may actually be scurvy, though not due to a dietary deficiency, but to some alteration in the normal metabolic picture which results in the animals being unable to synthesize adequate amounts of the vitamin.

other trace mineral elements. The entire ration of the fox contains up to 10 per cent of ground green bone or 2 per cent of steamed bone meal and, therefore, further mineral additions are unnecessary. They may even be harmful and are, naturally, expensive.

Manufacturers of commercial cereals keep well abreast of the developments in the field of nutrition and as soon as there is a proven need for some mineral, or other element, they will take the necessary steps to provide a source of adequate amounts in their products. This, in itself, is a very good reason for the use of commercial cereals in fox diets whereby there is assurance of constant high quality, proper mineral balance and little or no variability in the content of mineral elements. Though the question of minerals is under consideration here, it should also be remembered that the same reasoning applies to other dietary factors, such as vitamins.

This brief discussion might lead one to assume that no mineral supplement on the market is good. This in not true. Many of them are good but ONLY in instances where there is a proven need for them. The general, *injudicious* addition of mineral supplements to fox rations—just because someone else does it—should be heartily discouraged.

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FOX FEED FORMULAE AND FEEDING SCHEDULES

When one comes to the point of suggesting a feeding schedule of a definite nature, or a formula for general use, he is beset by many problems. First of all, he runs across the prejudices which have developed during the course of many years of experience on the part of the rancher. The rancher may have his own pet formula for various seasons of the year or he may use the same formula 365 days of the year and then, perhaps, we cannot all agree on just what "seasons" to divide the life history of the fox into as far as feeding is concerned.

In the first place, one must make an arbitrary division of the year into various seasons and must also bear in mind whether we are going to consider those adults destined for pelting in a different light from those which are to be retained for breeding purposes.

When, in addition, one attempts to suggest a possible formula for the feed under each of the special requirements, he is likewise beset by many embarrassing questions.

Therefore, it is wise to remember that, regardless of what can be put on paper, there are so many variables on individual ranches that the sum total of these is probably many times greater than suggested modifications of the diets which are to be presented here. By this is meant, simply, that there are large variations between animals both within one ranch and between ranches, there are even wider variations in the conditions under which these animals are maintained and the extreme of variables is encountered in the ones who actually do the feeding.

As a general, all-purpose ration and one which was used successfully over a long period of time and without any changes from one season to another—the same feed, day in and day out, to pelters, pups and breeders alike—the following is suggested as a basis. It must be understood that certain changes may be made in this ration from one season to another without throwing it into serious imbalance. These changes would consist of a general re-arrangement of the proportions of meat and cereal, or types of meat, depending upon the desires of the individual rancher.

Ground red meat	30.0 per cent
Viscera (tripe, lungs, melts, etc.)	10.0 per cent
Fresh liver	5.0 per cent
Ground green bone	5.0 per cent
Cooked fish (or homogenized condensed fish)	10.0 per cent
Commercial cereal	33.5 per cent
Vegetables (carrots, tomatoes, etc.)	5.0 per cent
Dried brewers yeast	1.0 per cent
Cod liver oil	0.5 per cent

If we will roughly divide the year into three parts, there appears to be a relatively good agreement between various feeding schedules which have been worked out. Some of the divisions are probably

longer than some ranchers would care to make them, and probably others would make more numerous and shorter divisions, but the following represents a fair average of feeding schedules which have been collected over a period of years. Each of the diets submitted was adapted to the three-season scheme and recorded. When the composite of all this information was prepared for this book, it was necessary to average out individual ranch variations during the periods covered.

The figures which follow represent average rations in three distinct areas of the country. The first column (1) is derived from the average figures for a large number of ranches in the eastern part of the United States plus some in eastern Canada. The second column (2) is developed from averages for fox farms in the midwestern states and, because of the much larger number of figures available, probably represents a better average figure than either column (1) or column (3). The figures in column (3), in turn, represent data collected from various areas not covered in the first two columns—mainly data from the western states and the western provinces of Canada.

COMPOSITE FORMULAE AND FEEDING SCHEDULES FOR FOXES

Period	*Ingredients*	*Percentage Composition*		
		(1)	(2)	(3)
SEASON I	Horse meat and fish	53.1	46.0	43.0
	Viscera	10.0	10.0	10.0
January 1	Bone	5.0	7.0	10.0
through	Liver	5.0	10.0	10.0
March 15	Commercial cereal	20.0	20.0	20.0
	Vegetables	5.0	5.0	5.0
	Brewers yeast	1.0	1.0	1.0
	Cod liver oil	1.0	1.0	1.0
SEASON II	Horse meat and fish	28.5	31.5	30.5
	Viscera	15.0	15.0	15.0
March 15	Bone	—	7.0	8.0
through	Liver	10.0	10.0	10.0
August 15	Commercial cereal	40.0	30.0	30.0
	Vegetables	5.0	5.0	5.0
	Brewers yeast	1.0	1.0	1.0
	Cod liver oil	0.5	0.5	0.5
SEASON III	Horse meat and fish	13.5	24.5	13.5
	Viscera	25.0	10.0	20.0
August 15	Bone	5.0	6.0	5.0
through	Liver	5.0	3.0	5.0
December 31	Commercial cereal	45.0	50.0	50.0
	Vegetables	5.0	5.0	5.0
	Brewers yeast	1.0	1.0	1.0
	Cod liver oil	0.5	0.5	0.5

For the period from January 1 through about March 15, the variations are entirely in the meat portion of the ration—in relative proportions of liver, bone, viscera and horse meat, depending largely

upon relative availability in the various areas. It should be noted that the *total* of the meat portion of the diet is the same in all cases when one adds the amounts of horse meat and fish, viscera, bone and liver, namely, 73 per cent.

For the period from about March 15 through the middle of August there are no significant variations, with the exception of an apparent lack of bone, and a generally higher cereal usage in diets reported from the eastern states. Despite the fact that no percentage figure is given for bone, it should not be deduced that easterners feed no bone during this period of the year. The reason for the blank at this point is that the variations were so large that it would have been unfair to attempt to create an average figure. The apparent lack of bone is, therefore, reflected in an apparently greater cereal usage.

Here again, there is relatively good agreement between certain areas as to the total amount of meat in the ration in relation to the amount of cereal. Thus, it would appear that there is generally good agreement in different areas of the country about what constitutes a good practical fox ration for the first seven and a half to eight months of the year.

When we come to the third arbitrary division of the year, however, the story is slightly different in that there are more variations, though they are not particularly significant, with the exception of the general use of more horse meat in fox rations in the midwest. Again, this may be the result of incomplete data from other areas and may be averaged out if a larger number of farms had been surveyed. Part of the discrepancy may also be due to the use, in certain parts of the country, of cereals containing meat at this time of the year and also to the wider use of pellets or cubes for those foxes destined for pelting.

It is a relatively constant finding that 5 per cent vegetables are included in the diet all year round. There is a general tendency to use about 1 per cent of brewers yeast all year round also, while the amount of cod liver oil is generally noted to be decreased at all times of the year with the exception of the first two and one-half or three months of the year.

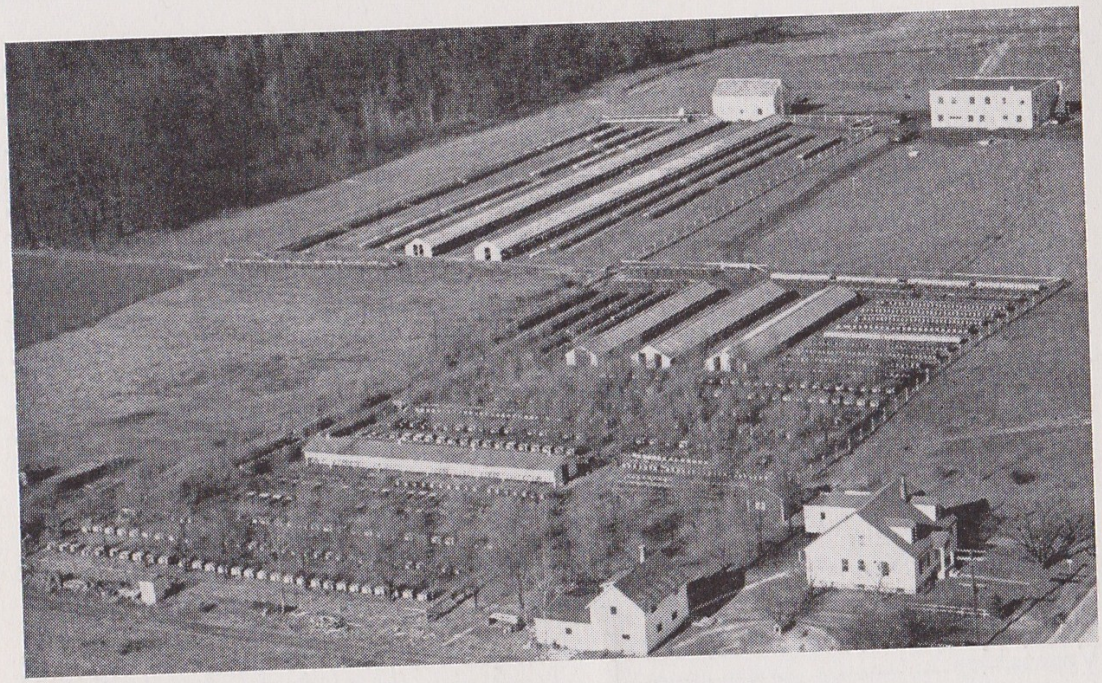
As a general summary, then, let us combine the averages shown above for the various regions of the country considered and perhaps we can strike a fair average figure for the composition of a fox diet throughout the year. At the same time, let us compare the figures just given for typical rations with the composition of the diet referred to earlier as a general, all-purpose diet. As shown in the following compilation, the general all-purpose ration given will strike a fair average for the composition of all other diets when the figures are considered over the period of a full year.

Ingredient	*General Ration*	*Season of the Year**		
Horse meat and fish	40	53	28.5	13.5 (1)
		46	31.5	24.5 (2)
		43	30.5	13.5 (3)
Viscera	10	10	15	25
		10	15	10
		10	15	20
Bone	5	5	—	5
		7	7	6
		10	8	5
Liver	5	5	10	5
		10	10	3
		10	10	5
Commercial cereal	33.5	20	40	45
		20	30	50
		20	30	50
Vegetables	5	5	5	5
		5	5	5
		5	5	5
Supplements (yeast and cod liver oil)	1.5	2	1.5	1.5
		2	1.5	1.5
		2	1.5	1.5

* The three columns listed are, in order, for the periods January 1 through March 15, March 15 through August 15 and August 15 through December 31.

The figures in parenthesis after column 3 indicate the area of the country: (1) eastern states and eastern Canada, (2) midwestern states and (3) western states and western Canada.

Although the tables above show a range of cereal usage between 20 and 50 per cent, depending upon the season of the year, many ranchers have increased the level of cereal fed to 60 per cent during the entire year and obtained good animals and pelts.



A Modern Mink Ranch

Photo, courtesy of American Fur Breeder. Maurice Gladfelter's Valleywood Mink Farm, Swanton, Ohio.

SPECIAL CONSIDERATIONS OF MINK

A. INTRODUCTION

It has always been the goal of the mink rancher to produce a large, healthy animal, one that is prolific and which will produce a superb pelt. This goal can be achieved only through the combination of a number of requisites. Of prime importance is the careful selection of breeding stock. Then, there must be efficient management of the ranch, included in which is the very important demand for sanitation and, just as important, the demand for a good, adequate and wholesome food supply.

It is not possible for the rancher to start with poor stock and have large production and superb pelts, no matter how good the feed, if that starting stock and additions made to it are inherently poor. On the other hand, good stock can be, and has been, ruined by poor feeding. In between lies the possibility of starting with average to good stock and maintaining a high standard of production and quality through the medium of a planned breeding program and good food properly fed. There is ample proof in the annals of the mink industry that good stock and proper feeding are a most desirable combination and there is also proof that good food alone will assist in the production of better pelts and larger litters.

When mink ranching was in its infancy, and for some time thereafter, the problem of a meat supply was not a difficult one.

There were plenty of horses and cattle that became too old for further use on farms, or had been injured in some minor way, that could be bought at a reasonable price. This meant that the meat portion of the mink diet was not a serious problem. The cereal portion, likewise, was a relatively simple matter after commercial cereal mixtures came into the picture. In meat and cereal, the mink rancher had the basis of a satisfactory diet when it was supplemented with a source of fresh vegetables, ground green bone for minerals, and a source of vitamins A and D.

During the course of the last war, the meat situation became critical and the cereal market was also restricted. It is during such times of stress and strain that we begin to learn more about the real nutritional requirements of the animals we deal with—and mink were no exception.

Although there has been considerable research work done to date, the question of what constitutes a *complete* and adequate diet for the complete life cycle of the mink is unanswered. There is only a limited amount of information which can be set down in black and white as a definite plan to be followed by all mink ranchers. The moment one tries to set specific limits on what must, or must not, go into a mink diet, he is in trouble. The same is true with respect to the correct percentage composition of the diet.

It is possible that a man might survive, and even grow fat, on a daily diet of four or five teaspoons of yeast, half a pound of meat, one potato, half an ounce of cheese and half a glass of milk a day but another man on the same diet might actually starve to death. Thus, in terms of QUANTITY of food alone, such a diet may or may not be adequate.

The same might well be said to be true of mink. The appetite and condition of the animals and the judgment of the caretaker will have a bearing, within certain limits, on the quantity of food to be given. Therefore, the absolute QUANTITIES of food fed are the concern of the rancher himself; but there is another side to this story and that is one of QUALITY. This latter is determined by the choice of ingredients, a knowledge of why certain food items are desirable and a knowledge of how to use them efficiently.

Mink are typically carnivorous animals and, therefore, just as in the case of the fox, it has been more or less taken for granted that some fresh meat is required in the diet. This would provide for adequate protein or body-building material. In addition, the ration should contain some carbohydrate and fat to meet the energy requirement of the animals. This energy may be derived partly from the meat and partly from the cereal portion of the diet, since both will provide some fat. Cereals containing mainly carbohydrates will be a good source of readily available energy. In addition, it is well established that certain minerals, such as calcium, phosphorus, iron,

copper, iodine and possibly others are required in certain definite, though as yet undetermined amounts. Then, too, mink must have their daily quota of vitamins. The question of sources for minerals and vitamins is relatively simple to answer. Meats and cereals will provide mineral elements and vitamins depending upon the source of such meat and the reliability of the cereal manufacturer in including them in his commercial formula. In most instances, additions of sources of certain minerals and vitamins have been prescribed in order to safeguard against a possible deficiency of certain factors.

B. RATION VARIATIONS

There are many rations, of varying composition, in use on ranches today. Not only do the individual ingredients vary, but the relative proportions of meat to cereals and other ration components also vary widely. In general, it may be said that most of these diets have proven adequate for mink.

It has usually been thought that the mink was perhaps more fastidious than the fox, but the wide variety of diets in use today with good success seems to be proof for the statement that mink can utilize a wide range of nutritive ingredients.

It is very desirable to provide adequate feed for both male and female kits so that they will reach sexual maturity in time for their first breeding season, but it is a decided mistake, once that growth and early maturity have been achieved, to continue to feed these animals excessive amounts of food to the point where they become excessively fat and unfit for the breeding herd.

It is essential that all animals should be fed as individuals and given just enough feed so that they will clean it up and still be slightly on the hungry side. This is a fine point of judgement for the rancher to determine and one which warrants special attention.

As is true in the case of studies which have been made with foxes, most mink experiments have been done with small numbers of animals and over rather limited periods of time, with the result that it is rather hazardous to attempt to draw any very general conclusions which will fit every particular case.

It is the general contention of mink ranchers that suitable adjustments should be made in the feed formula and feeding schedule during various seasons of the year. In the case of mink, the number of seasonal variations is apparently greater than in the case of the fox.

In the spring, when the female is nursing her litter, she needs a variety of ingredients and a large amount of food of high digestibility. At other times of the year this is not so important. During the summer, it appears that adult animals need little more than a maintenance ration, though this should not be construed as meaning "just any old feed", since this period of life is an important one due to the fact that the animal is then making preparation for the develop-

ment of a heavy and lustrous coat of fur which will mean the success of the ranch financially. Diets at this time of the year should be balanced nutritionally to supply all of the necessary factors but should be fed in amounts which are not excessive. It is important that young, growing mink receive a diet containing a wide variety of palatable and highly nutritious ingredients since this is the feed wherein lies the future of the ranch. Rations fed to kits must, of necessity, be carefully formulated and nutritionally complete and, above all, fed judiciously.

It is important to remember that it is always possible to overfeed a developed mink. The digestive tract of the mink is relatively short and the feed, therefore, must be highly and readily digestible, since, because it passes through the digestive tract in such a short time, the nutritive efficiency of the ration will be aided if the rancher provides ingredients which can be readily assimilated.

When it comes time for another breeding season, it is important that the animals be in good condition—neither underfed nor overfed. The rancher's own experience and thorough knowledge of the peculiarities of his individual animals are the best possible guides as to how much to feed after a complete, well-balanced diet has been formulated.

C. PROTEINS

As previously pointed out, mink are typically carnivorous animals and, therefore, it has been customary to include a generous proportion of meat items in the diet. However, experiments during recent years tend to indicate that less meat is required than was heretofore considered necessary. Recent experiments have shown that higher cereal levels may be used advantageously in the ration.

Generally speaking, the field of nutrition as it applies to mink has become more limited due to the use of a comparatively small number of basic formulae with ranchers using simple modifications of the general pattern to fit their own particular conditions. Also, there has been a more or less general pooling of information with the result that new-comers in the field have benefited from the experience of others.

The backbone of the meat portion of the mink diet has been horse meat, combined with a considerable proportion of other meats and meat by-products including liver and, in some instances, a large proportion of fish. A search of the literature on mink nutrition has revealed no scientific experiments directed at a determination of the minimum amount of protein required by mink at various seasons of the year. Just as in the case of the fox, we have no information about the specific amino acid requirements of the mink. Therefore, the best we can do at the moment is to provide an adequate source of protein whose amino acid composition is well balanced as judged by the requirements of certain laboratory animals.

If it be assumed that a mink ration has the composition outlined below, a calculation may be made of the total amount of protein which it will provide as follows:

Ingredient	*Lbs. used*	*Per cent Protein*	*Calculation*	*Lbs. protein*
Lean horse meat	35.0	18.0	35 x .18	6.30
Horse viscera	12.5	16.0	12.5 x .16	2.00
Ground green bone	5.0	19.2	5 x .192	0.96
Fresh liver	10.0	20.2	10 x .202	2.02
Cooked fish (smelt)	15.0	16.5	15 x .165	2.48
Commercial cereal	16.0	11.5	16 x .115	1.84
Fresh vegetables (carrots)	5.0	1.1	5 x .011	0.06
Dried brewers yeast	1.0	48.5	1 x .485	0.49
Cod liver oil	0.5	—		—
Totals	100.0			16.15

This example should not be construed as indicating that the mink diet must contain this amount of protein, and in addition, it should be noted that this calculation is prepared on the basis of ingredients "as is" before the addition of water. The calculation is so made due to the fact that various ranchers may add different quantities of water to such a formula, and it is therefore most desirable to make all calculations on such a basis that adequate comparisons may be made.

Now, if it be assumed that 50 pounds of water are added to bring this mixture to feeding consistency, there will be 150 pounds of wet feed containing a total of 16.15 pounds of protein. Therefore, the percentage of protein in the diet, as fed to the mink, would be determined as follows:

150 pounds contain 16.15 pounds of protein
100 pounds contain $\frac{100 \times 16.15}{150} = 10.76$ pounds of protein (10.76%)

According to some recent experiments reported by Bassett, a growing mink kit should receive a diet containing between 9.5 and 11.0 per cent protein on the wet basis as fed. Most mink diets in use today probably contain more protein than this, and on the basis of the results obtained by Bassett, such rations would be unnecessary and uneconomical. Further work will be required to confirm these preliminary findings but the best available information indicates that 9.5 to 11.0 per cent protein in the diet, as fed, is sufficient.

Various types of experiments concerned with meeting the protein requirements of mink have been carried out, and the following represents a cross-section of this work with such recommendations as the various authors have seen fit to mention.

A rather extensive series of trials has been conducted to determine the extent of digestibility of the various protein components

of mink rations. One of these series involved a total of 61 mink fed thirteen different diets. Six of these diets were made up of animal products supplemented with cereals, one was a commercial dog food which was fed alone as well as in combination with other meats and the others consisted entirely of such items as horse meat, canned fish, beef tripe, beef spleen, horse liver and a mixture of equal parts of horse meat and canned fish. The animals for these tests were maintained in special metabolism cages where their feed consumption and excretion of urine and feces could be followed closely and accurately. These animals were also fed so-called "fecal markers." This is the addition of a dyestuff or other colored material to the diet on some certain day. When the fecal material is excreted, it is possible to observe this material in the droppings. By such means, it is possible to tell when the test diet has passed through the digestive tract. By using these fecal markers it was determined that when feed is consumed, it is completely eliminated by the mink in less than fifteen hours. This is a relatively short time and is probably accounted for by the shortness of the digestive tract of a mink. The total digestive tract in this animal is about five feet long and its ratio to the length of the body is, therefore, about one to four (i.e., it is about four times as long as the body) while in animals such as the dog and fox, the ratio is nearer one to six (i.e., the digestive tract of these animals is about six times the body length.)

Of the total dry matter consumed on all these diets, between 70 and 78 per cent was digested. It was generally observed that the higher digestibility of total dry matter occurred when the ration contained raw meats. In all diets except one, the crude protein was more completely digested than was the dry matter.

It was found, for example, that 93 per cent of the protein contained in raw horse liver was digested, as was 86 per cent of the protein of raw horse muscle meat or 84 per cent of the protein of raw beef spleen. No significant difference in digestibility was found between the protein of raw horse meat or raw beef, but the protein contained in such materials as beef scrap and fish meal was only digested to the extent of about 72 per cent.

In order to study the effect of cooking and drying on the digestibility of horse meat, a test was made using horse meat which was cooked under pressure in an autoclave (15 pounds of steam pressure) for two hours. When this material was tested, the digestibility of the protein was found to have been reduced to less than 73 per cent. On the other hand, when horse meat was dried at a temperature of 80 degrees Centigrade for a period of 24 hours, the digestibility was reduced, but not quite so much. In another series of tests, it was found that the protein of canned fish was digested to about the same extent as in the case of cooked or dried meats—again less than raw meat.

It was interesting to note from this work also that the digestibility of raw horse liver and beef spleen was as good as or better than that of horse muscle meat, while the digestibility figure for beef tripe was slightly lower. This lowered digestibility was attributed to a larger percentage of connective tissue than would be found in the muscle meats or liver.

Most of the mink rations in common use today contain large quantities of meats and meat by-products and it has, therefore, become customary to believe that this large percentage of meat is necessary for the production of high grade pelts and large litters. This is all well and good, but what is the rancher to do if he cannot find enough raw meat available? The problem of finding enough raw meat at reasonable cost became a great problem during the early years of the last war and has not yet been solved. When such a problem as this comes along, of course, there is new impetus given to a study of possible substitutes for the scarce or expensive commodity. This has been true in the case of mink. The studies, for the most part, have been on relatively few animals and were carried on only over short periods of time, so that the results must be viewed in the light of these limiting factors. Some of the apparent differences might have been evened out if the animals had been more numerous and if the experiments had lasted longer. Much of the work done in this direction, while indicative, needs expansion with larger numbers of animals fed over a longer period of time.

The other alternative to finding a substitute product to tide us over the lean period is to learn how to use what we have at hand in a more efficient manner and avoid waste wherever possible. One of the best conservation measures in this direction, of course, is to feed the best possible ration from the nutritional standpoint and do not feed it beyond the capacity of the animal to utilize the elements contained in it. It is also advisable to avoid those losses which have been associated with excessive intake of proteins and keep the amount of meat within usable limits.

During 1947, the group at Saratoga Springs, N. Y. performed an experiment which illustrates this point. They used a total of 82 mink in this work and divided them, at random, into three lots. One of the groups received a diet containing 40 per cent meat, another a diet containing 60 per cent meat and a third containing 26 per cent meat. The last-mentioned group was supposed to have been fed a diet containing only 20 per cent meat, but preliminary trials were unsatisfactory and the amount was finally set at the 26 per cent figure. It is interesting to note that all of these diets contained about the same total percentage of protein, namely 14.2, 15.8 and 13.9 for the 26 per cent, 40 per cent and 60 per cent meat diets, respectively. These protein percentages are expressed on the moist or "as fed" basis and are slightly higher than the 9.5 to 11.0 per cent figure which they have more recently indicated. Inasmuch as the total protein

content of the diets was approximately the same, it might be assumed that the differences ascribed to the content of meat in the diet do not take into account the possibility of serious differences in the amino acid composition of the diets or some nutritive factor which is lacking in the diet containing 26 per cent meat. The results are most enlightening and showed, among other things, that the production of young did not vary significantly among the three diets. The proportion of bred females and the sizes of the litters obtained were quite similar. Losses were the same on all diets.

Records of the food consumed indicated very little difference in the amount of the three diets eaten by the mink. They concluded that adult female mink will retain their weight as well on a diet containing 40 per cent meat as on one containing up to 60 per cent, while breeding success, production of young and freedom from litter destruction are as favorable at a raw meat content of 26 per cent as at 40 or 60 per cent. Mink raised to weaning on diets containing 26 per cent meat were definitely smaller than those fed higher levels, though there was little to choose between the two higher levels. Because of this, they state that the most efficient ration for feeding mink kits up to weaning need not contain more than 40 per cent meat.

Various experiments have also been performed to test direct substitution of packing-house by-products for various proportions of the normal raw meat content at various seasons of the year. For example, tankage and liver meal (four parts of tankage to one part of liver meal) were substituted for one-half of the raw meat in summer rations for adult mink. Both the experimental animals and the controls maintained on a normal mink diet containing all fresh meat ate about the same amounts of food. The control animals were normal and healthy, but those on the test diet became unkempt, ragged, emaciated and generally were considered very unthrifty. Some had reddish fur that was badly matted, and they shed late. Two of the animals died and a third was transferred to the control ration to avoid death. It is evident from reading the above just what were the conclusions of the authors—the substitution was considered unsatisfactory in view of the losses suffered, the absence of gains in weight from summer until pelting and the general poor condition of the pelts.

Some twelve years ago another experiment was reported on the value of beefmeal as a partial substitute in summer rations for weaned mink kits. The substitution at that time was not found satisfactory, but certain rigid limits of food consumption were put on the animals and this was probably a limiting factor. This work was repeated later and extended with larger numbers of animals. The controls received a diet containing 40 per cent of horse meat and the test lot received a ration containing 20 per cent horse meat, the remaining horse meat being replaced by 6 per cent of beefmeal. The figure of 6 per cent of beefmeal was chosen because one pound of beefmeal (dry) is equivalent to about 3 and 1/3 pounds of fresh meat.

It was found that the test animals ate about 13 per cent more food than did the controls on a diet containing 40 per cent horse meat. This sounds like a lot—and is— and yet the workers were able to show a net saving in the cost of feed used. The pelts taken from the test animals were quite normal and comparable with those taken from the controls. The extra food consumption by the test animals was attributed, in part at least, to the lower digestibility of beefmeal when compared to raw horse meat.

Preliminary experiments have also been reported with mink in which tripe was used as a replacement for half of the meat in summer and fall diets. No significant differences could be shown in any regard at the conclusion of the trials. It was determined that the substitution of tripe for all of the raw muscle meat in rations fed to adults during the reproductive season was very unsatisfactory. There were fewer kits whelped and weaned, large losses were encountered and the old females did not maintain their weights.

Still on the subject of meat substitutes, there are reports of experiments in which mink kits were used to study the value of certain types of summer rations. In these trials, canned fish or a comparable quantity of fish meal on a dry matter basis, were substituted for one-third of the raw meat portion of the diet. There was no apparent differences in the general health of the animals when they were examined during the course of the last eight weeks of the experiment. No significant differences in color, quality, density and primeness of the fur were observed; therefore, this experiment was taken to indicate that the substitution was satisfactory, although there is no available record of production figures for the following year. In similar tests with adult females, the substitution of canned ocean whiting for one-third of the raw meat in the diet was found to be satisfactory. More recently, some ranchers have replaced as much as half the horse meat in the diet with homogenized condensed fish with highly satisfactory results.

These experiments and others which have not been mentioned were undertaken to determine the advisability of using certain desiccated products as partial substitutes for the raw meat portion of the ration. These studies have indicated that a large amount of raw meat, as generally used, is not only unnecessary for the production of good pelts but will add considerably to the cost of the diet. Results have been satisfactory, in general, when beefmeal, soybean oil meal, fish meal, corn germ meal, tripe, canned fish, homogenized condensed fish, poultry wastes, lungs, peanut meal and cottonseed meal were used as replacements for up to one-half of the meat in summer mink diets.

To conclude this section, there are a few general comments about meat products which should be called to every rancher's attention:

(1). If you should occasionally have a carcass from a dead horse

or cow and are tempted to use it, try the following simple test before feeding it to all your animals. Take small portions of meat from all the various parts of the carcass, grind them together and select three or four of your poorer mink. Use this meat as the entire meat portion of their diet for several days and observe the animals. If all is well after four or five days, it is generally assumed that the meat is suitable for consumption by the ranch as a whole.

(2). Meat from animals which are suffering from a generalized infection of the blood stream, which have fistula or infections where there is running pus should not even be considered as potential mink feed. Rigidly avoid the use of such carcasses as you have too much at stake to run the risk of losing even a few animals in such a gamble.

(3). Your local butcher may have available certain animal by-products which are not considered suitable for human consumption but which may be perfectly suitable for mink feed. However, these materials should only be used if they can be handled in a sanitary manner and used within a short time so as to avoid contamination or spoilage. Among these items might be mentioned lungs, spleens (melts), udders (cow bags), gullets, liver, heart, kidney and tripe.

(4). It has been determined by experience on certain ranches that chicken and turkey heads, as well as entrails from these birds, make good mink food. Some ranchers have encountered trouble when feeding raw poultry waste products and have found it desirable to cook such ingredients before using. The beaks should be chopped off, however. Jack rabbits and muskrats, when in season, have been successfully used also as part of the meat component of the diet. They must be handled in a sanitary manner and used only when fresh.

(5). Remember that it is possible to stunt animals from underfeeding them early in life. This is a mistake which cannot always be corrected later in the life cycle. While it is impossible to overfeed kits up to the time of weaning, older mink can be overfed, in some cases to the extent that they will make regular gluttons of themselves. Such overfeeding has been the cause of death in more than one proven instance. The most obvious measure is to watch the litters as they come out for food during the nursing period. Keep your eyes on the gluttons and separate them as early as possible from the rest of the litter and then feed them accordingly. It is also possible to spread the feed a little thinner, so to speak, by feeding such individuals twice a day, giving them less than a normal full feeding each time. This will prevent their gorging on one meal and consuming too much feed at one time.

LIVER FEEDING

Since liver is commonly used in mink rations at levels approximating 10-12 per cent, and its feeding results in generally better

Photo, courtesy of American Fur Breeder. A Pastel Mink owned by Dr. K. T. Orr and Son, Wayzata, Minnesota.

health and reproductive performance, its addition has been considered a wise one, though at times it may seen extravagant.

(This subject is discussed in detail in the section "Special Considerations of Foxes").

In the course of many nutritional experiments conducted by many different individuals and research groups, the feeding of diets containing 10 per cent of fresh liver has produced satisfactory results in animals which were in poor condition as a result of one or more of a number of nutritional disturbances. Recent evidence indicates that there is, apparently, still another factor (or factors) in fresh liver which is essential to normal nutrition. This same postulation has been made in connection with studies of mink nutrition by use of purified diets (which will be referred to later) in these terms: "preliminary observation indicates the existence of another factor present in liver distinct from the known vitamins which is seemingly necessary for maintenance of body weight and hemoglobin regeneration".* Such a statement as this lends scientific footing to the recommendation for the use of fresh liver in mink diets. Rather than add a conglomeration of unproven materials to the diet, it is wiser to use natural materials wherever possible, since they are the best guarantee of good results.

Because of the scarcity of fresh liver at times, an investigation was undertaken by one of the authors to find a suitable substitute for fresh liver. One of the best of these is a product composed of whole, sound livers which have been chopped, cooked and dehydrated.

* A. E. Schaefer, C. K. Whitehair, and C. A. Elvehjem, Proc. Soc. Expt. Biol. Med., *62*, 169, (1946).

Although, this material is practically devoid of vitamin A, it contains important amounts of other vitamins, especially riboflavin, niacin and pantothenic acid. It has suffered virtually no loss of protein content during this treatment and, therefore, should be excellent for mink feeding. The lack of vitamin A is not considered serious, since the inclusion of one per cent of cod liver oil in the diet, or the use of a reliable commercial cereal guaranteed to be sufficiently fortified with vitamin A will make up for this deficiency.

In conducting tests with this material, a total of 58 mink was used. Group I (control) was fed a ranch stock diet and Group II (test) received the experimental diet.

It was previously determined that one pound of this dehydrated material was roughly equivalent to 3-1/3 pounds of fresh liver (because of removal of the moisture content) and, therefore, was used at a level of 3 per cent of the diet while the control diet contained 10 per cent of ground, fresh liver. The diets were identical in all other respects.

The test was conducted over a period of ten months and the rations were made up to volume and consistency for feeding with water and the trial was conducted as nearly as possible, under actual ranch conditions. Inasmuch as the test was started in March, there were females with litters included among the test animals. These received a feeding in the morning (a small portion) in addition to the full evening feed given all the animals. After the kits were weaned, all animals were maintained in individual small pens.

During this period of ten months, all mink in the experimental group maintained food consumption, body weight and pelt quality on a par with those in the control group.

No losses were encountered which could be attributed to the rations used. Kits produced from females on both diets grew at the same rate and developed fully to the same extent. It was apparent from this test that this particular dehydrated liver product was a suitable substitute for fresh liver. In addition to the experimental trial, this product has been used in the field and many ranchers have indicated that it is satisfactory in their diets.

FISH FEEDING — THIAMINE DEFICIENCY

There is no need here to repeat the long story about the discovery of the cause of Chastek Paralysis as it is observed in mink. The rancher is advised to read the section on fish feeding and thiamine deficiency under "Special Considerations of Foxes," since the facts outlined there also apply to mink.

The number of cases of Chastek Paralysis (or thiamine deficiency) observed in mink has been smaller than in the case of foxes. The reason for this is not clear as yet, since rations containing a

large percentage of raw fresh-water fish have been successfully fed to mink over long periods of time. On the other hand, diets containing as little as 10 per cent of the meat portion of the diet as raw fish have produced clear-cut cases of thiamine deficiency.

The statement seems warranted here again that if fresh-water fish, and apparently also certain species of salt-water fish, are used —especially suckers, smelt, buffalo fish and carp—it is advisable to cook them under pressure for at least 20 minutes before using. This cooking will destroy the enzyme present in fish viscera and in the muscle meat, which is responsible for the destruction of the vitamin, thiamine.

If there are no facilities available for cooking the fish of the types mentioned above, it is suggested that they be used only on alternate days, or for a period of two or three consecutive days followed by a period of the same duration with no fish in the diet. These latter two measures have proven quite successful with mink. At this point, reference should also be made to the section on fox feeding for a discussion of the merits of homogenized condensed fish in this regard.

THE VALUE OF BLOOD IN MINK RATIONS

Blood possesses a unique property in that it constitutes a powerful lure, or bait, for certain classes of animals, such as mink. This will ensure that a ration will be eaten with great relish and avidity.

The use of at least a small amount of fresh blood in the diet has been an almost universal procedure among mink ranchers. This fresh blood has, in some instances, been purchased as such, but more commonly has been obtained directly from the animals slaughtered for meat used in the ration. In most instances, this blood has been fairly well handled so that it is safe to feed to mink. However, it must always be borne in mind that fresh blood forms an excellent medium for the growth of bacteria and other micro-organisms and, therefore, must be handled with extreme care. This constitutes a hazard in its feeding; at the same time requiring additional labor for its proper handling. It must be quickly frozen, if not used immediately, and, therefore, requires freezer space. In addition, it is necessary to thaw out, at least partially, before inclusion in the feed mixture. This repeated handling is fraught with potential dangers from contamination.

Ranchers who do not have an available supply of fresh blood may find it advantageous to use spray-dried whole blood as a substitute for the fresh blood. This material can be stored without refrigeration and will maintain all its desirable properties, including its complete solubility. This makes for easy and convenient handling—an important factor in the economy of the mink ranch. It is entirely

safe to use and therefore eliminates one of the hazards in the adequate feeding of mink, namely, that of contamination, which may occur readily with a product such as fresh blood.

D. FATS

There are relatively few reports in the literature of mink farming which deal directly with the role of fat in the nutrition of these animals. As a matter of fact, some ranchers have even felt that all excess fat should be trimmed from meats before feeding to mink. It was reported by some individuals that mink fed on diets containing meat with a high percentage of fat did not produce as large litters as those fed diets containing a minimum of fat.

However, both fats and carbohydrates are excellent sources of energy but much more work is needed before it can be stated definitely at what levels they can be included in the diet safely and to the best advantage.

In some early experiments designed to study the digestibility of meat proteins from various sources, it was also observed that the fat present was generally well utilized. The apparent digestibility of fats, in most cases, was higher than that of either the protein or the total dry matter, and on the basis of such information, it would be reasonable to conclude that fat is an excellent source of energy for mink.

Some more recent experiments have been performed by Wilke and co-workers, in which groups of mink kits received diets containing added fat at levels of 10, 20 and 30 per cent with a control lot receiving no added fat. Suitable adjustments in protein level were made to allow for the lowered food consumption of animals which received diets having a high energy value.

During the period from weaning to pelting, there was a striking decrease in the amount of feed needed by mink when they received liberal amounts of fat. For example, the amount of mixed feed eaten was decreased 35 per cent when 10 per cent fat was added, 59 per cent when using 20 per cent fat and 66 per cent when the addition of fat was at a 30-per cent level.

Male mink did not show significant weight variations during the course of these trials but females receiving 30 per cent fat in the diet were heaviest. Pelts from all groups were similar and of the same quality as those from mink fed a standard ration containing 40 per cent horse meat and liver.

Such experiments as these indicate a possible method of reducing feed handling and storage problems but require further confirmation before final acceptance.

It is important to recall here again that the presence of some fat in the diet is an aid in the proper absorption and utilization of the fat-soluble vitamins A and D and that certain components of fats (the so-called "essential fatty acids") are very important in the nutrition of other species for the promotion of growth and prevention of skin diseases.

In a survey of many diets, it appears that a large number of ranchers prefer to remove cod liver oil from the ration of animals being kept as breeders about July 1 and omit it until some time in November or December. It is also believed by some that no cod liver oil should be fed to pelters since it is thought to have an undesirable effect on the quality and color of the pelts produced.

This ill effect, if there truly is one, is probably a function of the fat itself and not due to the content of vitamins A and D. This recalls again the experiments of G. Ennis Smith on the feeding of cod liver oil, cod liver meal, fat meat and other oils and fats during the summer and fall months. He noted that the inclusion of these fats in the diet tended to adversely affect the shedding of the fur and inhibited the production of black pigment in the new fur, with the result that the pelts were an abnormal brown shade.

However, it must be concluded that the full answer to this question of the desirability of fat in the diet has not been found and the problem requires further study.

E. CARBOHYDRATES

Though mink are typically carnivorous animals and, therefore, large meat eaters, cereal should be included in the ration. At the present time there is relatively little information available to indicate just what proportion of the diet should be carbohydrates. There is, likewise, no information as to what constitutes the most desirable ratio between the two components of the carbohydrate fraction of the feed—the so-called N.F.E. (nitrogen-free extract) and crude fiber.

The range of cereal products in mink rations is confined within rather narrower and lower limits than is the case with the fox. Most rations will be found to contain between 15 and 25 per cent cereal, though the actual usage will depend on the ranch, its location and the season of the year. Recent experiences of ranchers indicate that considerably higher levels of cereal may be used to good advantage in the mink diet.

The total caloric requirement of mink in terms of calories fed per pound of body weight per day was estimated by Palmer some years ago as being in the range of 120 to 130. Work at Cornell University has indicated figures in the range of 100 to 150, with a general average figure of 124, which is considered to be in excellent agreement with the earlier data of Palmer and somewhat higher than

earlier figures suggested by G. Ennis Smith. Per unit of live weight, this means that the caloric or energy requirement of the mink is about twice that of the fox. However, it would appear more logical that the caloric requirement be based on the surface area of the body of the mink rather than on body weight since these animals are evaluated on the basis of their pelts and not body weight. The same, likewise, may be said to be true for foxes. However, we do not have a good estimate of the body surface area of the mink or fox from which to make this calculation. For the present, energy requirements have to be based on body weight.

The caloric figures given above are those for maintenance, but when an extra strain is placed on the body, such as in periods of rapid growth, pregnancy and lactation, this figure should be increased —but by an amount which is unknown at the present time.

Commercially prepared cereal feeds made by responsible concerns contain those vitamins and minerals considered necessary for the normal nutrition of mink. These vitamins and minerals are usually present in the correct proportions when the materials are fed in accordance with the directions supplied by the manufacturer. Most rations in general use contain about 5 per cent of fresh vegetables. In the absence of properly formulated cereal feeds, the addition of certain vitamin concentrates is advisable during certain seasons of the year to round out the picture of complete nutrition as far as it is known for the mink today.

Inasmuch as there is a difference of opinion among ranchers and research workers studying mink nutrition as to whether the cereal portion of the diet need be cooked, it should be noted here that the cooking and toasting of cereals will increase their digestibility and this is probably one reason why processed cereals have come into use in recent years on such a large scale. Feed manufacturers have made exhaustive studies of the proper conditions for cooking these cereals, therefore, products from responsible manufacturers are considered to be highly satisfactory. In addition to deriving benefit from the long experience of the cereal manufacturers, the rancher is assured of a constant supply of uniform material of high quality from one lot to another. This is an important consideration, since it has been adequately demonstrated that abrupt changes in the diet of the mink may have serious consequences. By being assured of a relatively constant cereal formula, a great burden of uncertainty has been removed from the rancher's mind. It is important to recognize, too, that the preparation of a home-made cereal portion for the diet is a tedious and involved process requiring considerable equipment for grinding, mixing and cooking, plus valuable time. Commercial cereal feeds are easily stored in a cool, dry place without special attention and the feeder also has the guarantee of the manufacturer as to its content of suitable ingredients, and wholesomeness.

Pelts from mink fed on Kellogg's
Courtesy Otto H. Grosse, Northwood Fur Farms, Cary, Illinois

F. VITAMINS

In the case of mink, the vitamin story is not quite so easy to tell as it was in the case of the fox. There are great areas of vitamin knowledge which have never been studied in relation to the mink and it is not possible, at the present time, to indicate with any degree of assurance, just what are the minimum vitamin requirements for the mink at any stage of the life cycle. However, such studies as have been made are reported in part in the sections which follow.

1. VITAMIN A STUDIES

In recent research reported by Bassett and co-workers, a study was made of vitamin A in the nutrition of mink. Sixty mink kits were allotted at random into 10 groups. For different groups of animals, the basal diet was supplemented with vitamin A at levels of 0, 50, 500, 2500 and 5000 I.U. (International Units) per pound of moist, mixed feed. Other groups receiving the same supplements of vitamin A received, in addition, 20 milligrams of ascorbic acid to test its effect on growth and to see whether the administration would have any effect on the vitamin A requirement.

With the possible exception of the zero level of vitamin A, there were no differences in weight gains that could be correlated with the the amount of vitamin A administered or with the omission of ascorbic acid from the diet. Differences in food consumption did not appear to be related either to the intake of Vitamin A or that of ascorbic acid.

Typical symptoms of vitamin A deficiency have been described for foxes and other animals, but none of these were observed in the mink on this test. This work, therefore, could be taken as evidence that the vitamin A requirement of mink per pound of mixed feed is lower than that of foxes, though it is possible that their liver reserves of vitamin A were adequate to help carry the animals through until pelting time.

Examination of the pelts revealed no trend that could relate quality of the pelt produced to the intake of vitamin A.

It was also observed that the vitamin A content of the blood serum and liver of mink increased as the amount of vitamin A fed was increased, and was greater when ascorbic acid was also added to the diet. This evidence would tend to indicate an unexplained relation between vitamin A and ascorbic acid (vitamin C) in the nutrition of the mink.

The interesting conclusion that may be drawn from this work is that both growing and pelting rations fed to mink apparently contain sufficient vitamin A or its precursors so that the addition of vitamin A concentrates is unnecessary. The usual dietary sources of vitamin A (and its precursor carotene), such as vegetables and fresh liver probably contain sufficient vitamin A to meet the needs.

2. VITAMIN D STUDIES

No information on the vitamin D requirement of mink is available. It is assumed that sufficient quantities of this vitamin are obtained from the action of sunlight, to which the animals are exposed for most of the year, or from concentrates such as cod liver oil which supply ample amounts of vitamin D. In addition, the best com-

mercial cereal products now contain vitamin D and this provides another valuable source of this factor. Vitamin D is, apparently, of minimum concern to the modern mink rancher.

3. VITAMIN B COMPLEX STUDIES

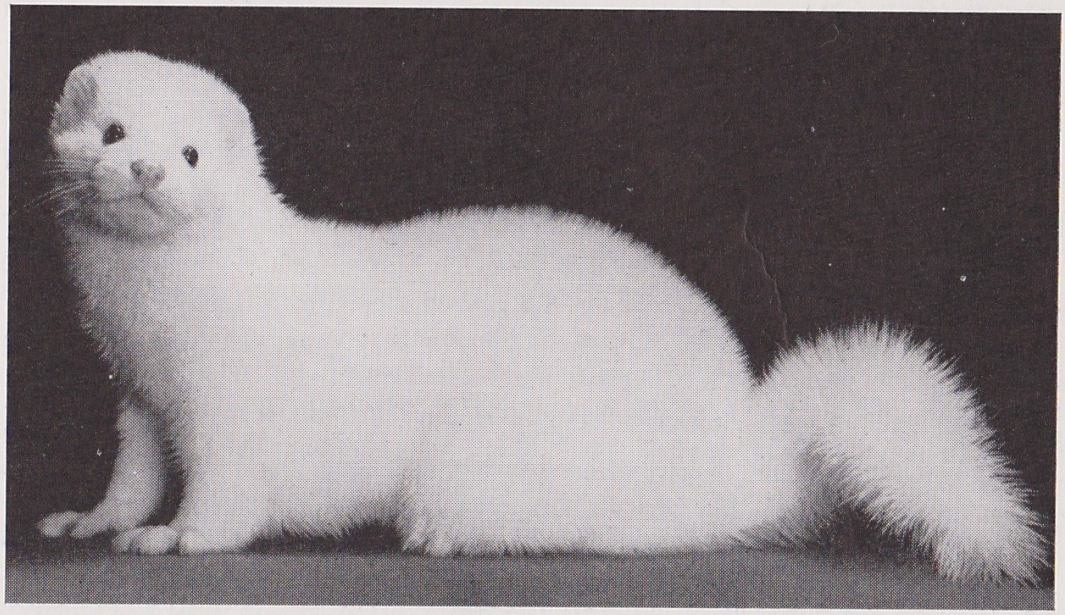
Very few studies have been reported on research directed toward a determination of the requirements of the mink for the various members of the vitamin B complex. No mention will be made here of one of these factors (thiamine or vitamin B_1) since it has been referred to in studies of Chastek Paralysis. The studies of other vitamin B complex factors are not as complete as in the case of the fox; therefore, such work as has been reported will be considered under this general heading rather than devoting space to each individual factor.

The purified diet technique used in studies of the vitamin requirements of laboratory animals, dogs and foxes, has also been applied to mink. This constitutes quite an advance in scientific nutrition studies insofar as mink differ widely from other species which have been investigated. The mink used for this work had been maintained on a diet containing 72 per cent horse meat (including bone), 10 per cent fresh liver, 12 per cent cereal mixture and 6 per cent tomato puree prior to the initiation of these experiments. The trials were largely confined to a study of the importance of folic acid in mink nutrition and involved studies on three different types of basal diets. One of these was the same as that used in the studies with foxes, already referred to. A second contained 30 per cent protein, achieved through the addition of extra casein at the expense of sugar, while the third contained 19 per cent of casein with an additional 10 per cent of gelatin included at the expense of sugar.

It was generally observed that a period of about two weeks was required to change the animals over from their normal diet to the purified ration, though some individuals started eating it right away. This change-over was accomplished by gradually increasing the amount of purified ration and decreasing the amount of stock mink diet indicated above.

At first, there was a rather general weight loss in mink maintained on the normal purified diet and then their weights tended to remain constant, but after about 10 to 13 weeks on this diet, again there was a severe loss of weight. The animals became generally weak, irritable and had watery feces. In one individual there was also a loss of appetite and vomiting. The addition of folic acid brought about an immediate, drastic improvement in the condition of one mink, and the symptoms of diarrhea, irritability and weakness disappeared.

The basal diet was then modified to include more casein so that the protein level of 30 per cent was attained. After about 9 weeks on



Photo, courtesy of National Fur News. White Mink from the Fur Ranch of Nirschl and Quinlin, Portland, Oregon.

this ration, the mink began to lose weight markedly. The administration of the vitamin biotin at this time was apparently without effect, since weight loss continued and the mink showed the same symptoms as before. There was then an immediate response when folic acid was administered.

On the modified basal diet including 10 per cent gelatin, all the animals began to lose weight after 4 to 8 weeks. Supplementation with biotin was again ineffective and body weight losses continued. Some of these mink actually lost 50 per cent of their body weight and showed bloody feces, irritability, general weakness and loss of appetite. Again, administration of folic acid was effective and there was an immediate remission of the symptoms of the deficiency. After this second addition of folic acid, further supplementation gave negative results.

Five mink were also maintained on the original purified diets supplemented with only six synthetic vitamins. These were given additional supplements of whole liver or liver fractions, while others were maintained without additions of liver or liver fractions. In the case of those receiving no liver preparation, there was again evidence of a deficiency which was remedied by the administration of folic acid.

However, preliminary evidence indicates that there is a requirement on the part of mink for an additional factor(s) which is supplied by fresh liver. The nature of this is entirely unknown at the present time, though it is apparently distinct from any of the known vitamins. The possible role of biotin in the nutrition of mink is still a mystery and efforts to produce an uncomplicated deficiency of this factor have not been successful to date.

It is also interesting to note that the administration of folic acid early in the deficiency state cured the condition known as hemorrhagic enteritis. The symptoms observed in this deficiency include bloody feces, the finding of fatty livers, an ulcerative type of hemorrhage localized in the stomach with large volumes of free blood in the stomach and intestines. When folic acid was included in the diet from the start, this condition was prevented. This finding may provide at least part of the answer to the cause of the condition described in mink for many years and commonly referred to as "hemorrhagic enteritis."

4. ASCORBIC ACID (*Vitamin C*)

Little is known about the possible role of this vitamin in mink nutrition though it has been assumed for many years that there was no dietary requirement for it for mink. In view of the recent work on vitamin A by Bassett and co-workers, however, it is possible that there may be some relationship between vitamins A and C, though this is not clear at the moment. The average mink ration usually contains about 5 per cent of vegetables and this should provide an adequate source of vitamin C for these animals.

5. VITAMINS E AND K

There is no good evidence to prove that either of these vitamins is required by mink. The claim of many ranchers that additions of wheat germ, wheat germ oil or corn germ, as sources of vitamin E, should be made to the diet at certain periods of the year cannot be justified on the basis of present evidence concerning the nutritional importance of this factor. Vitamin K is of relatively wide occurrence in all green, leafy materials and should be present in adequate amounts in the normal constituents of the ration.

In connection with the studies of the requirements of mink for certain of the factors of the vitamin B complex, no response could be obtained by addition of either of these factors to a basal diet supplemented with members of the vitamin B complex.

G. MINERALS

It is quite possible for a mink rancher to have a good diet for his animals and still not be satisfied with this phase of his mink raising program. By this, it is meant that he has an apparently normal feeding formula and schedule, yet he hears that, by some addition or other, another rancher increased his production or improved the quality of his pelts. Then, rushing into the situation, the first rancher makes the same addition to his diet. The results may be either good, bad or indifferent. In many instances, however, the results have been bad—an old story that many have learned through experience. Instead of adding the "magic ingredient", this rancher

should have left well enough alone, at least until he had time to find out just WHY this special supplement worked in the case of the second rancher.

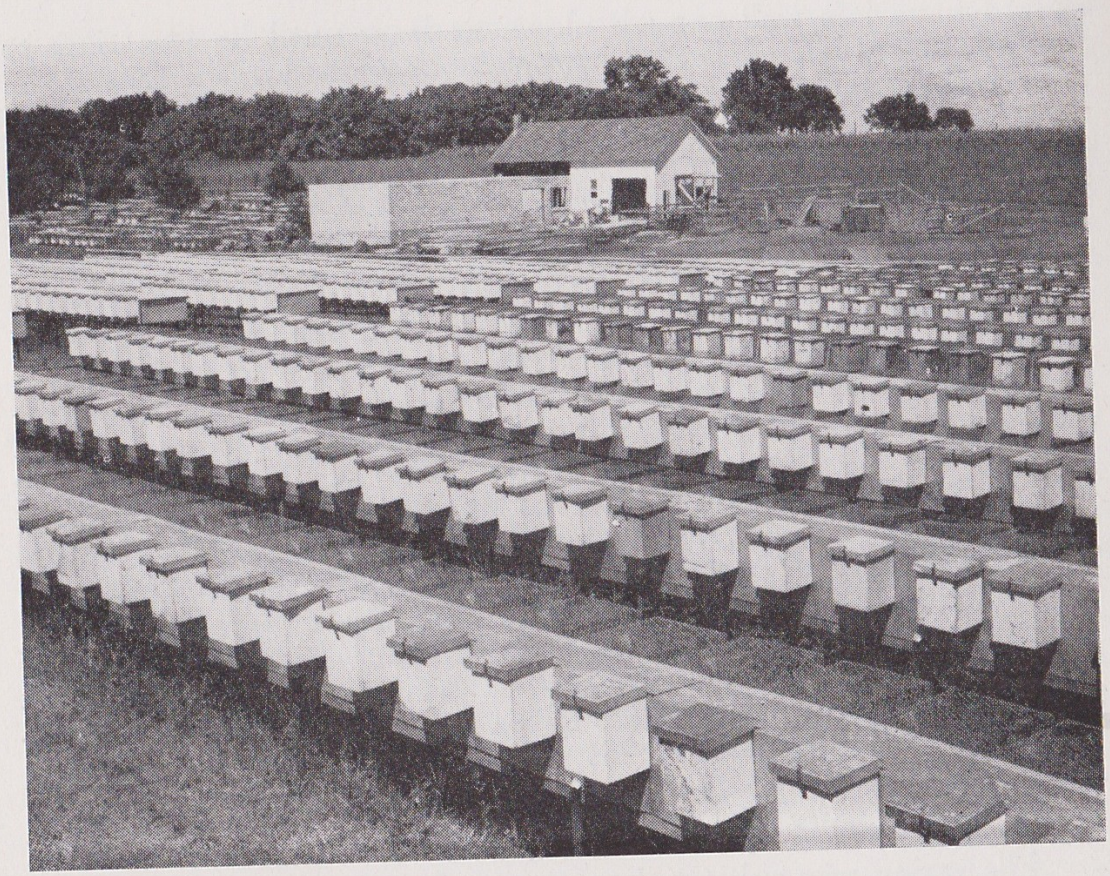
This has been true, to some extent, with regard to the protein, fat and carbohydrate portions of the diet, and to a limited extent, with certain of the vitamins, but this experimentation—if it can be called such—has been most evident when we consider minerals.

There are many cases similar to the one mentioned. Several years ago, in connection with experiments designed to study factors involved in or influencing the production of urinary calculi, a rancher heard of findings that vitamin A and the ratio of calcium to phosphorus were important considerations. This rancher had observed no cases of urinary calculi in his mink but, in the belief that an ounce of prevention was worth a pound of cure, he took the findings literally, without studying his own ration and bought a large supply of calcium carbonate and started adding it indiscriminately to his feed each day. This was in early July. To his great consternation, the following spring he encountered his first case of urinary calculi. Before the end of the whelping season, his losses had amounted to just under 5 per cent of the females on his ranch. Immediately alarmed and discouraged, and probably also slightly suspicious of the research workers, he explained what he had done.

His ration was subjected to chemical analysis for calcium and phosphorus and it was found that the ratio of calcium to phosphorus in that current diet was about 5 to 1. This is seriously out of balance and such ratios as this were found previously to lead to the production of urinary calculi in many experiments.

It was even more evident that this dietary imbalance of calcium and phosphorus was the important factor in this rancher's case when his diet was analyzed again after the supplement of calcium carbonate was removed. This latter analysis showed that his diet contained calcium and phosphorus in a ratio of 1.83 to 1, which is within the normal range. This serves as an example of what can happen unless all the necessary facts are known for each special case studied. If this rancher had been content to leave well enough alone, his records would have been better.

This is just one example intended to point out the fallacy of excessive mineral fortification of the mink ration. If the diet contains about 5 per cent of ground green bone or 2 per cent of steamed bone meal and is otherwise of normal composition, no further mineral supplementation is required or advisable, since the selection of meats and the properly-balanced cereal portion will provide sufficient of the mineral elements to meet the demands of the mink.



Furring Pens

Photo, courtesy of American Fur Breeder. Christensen Bros., Minkery, Cambridge, Wisconsin.

MINK FEED FORMULAE AND FEEDING SCHEDULES

The proper ration to be used for the adequate feeding of mink throughout the year is an important consideration, but it is not yet possible to give the complete answer to the question, "What shall I feed my mink?" While the composition of the diet is of great importance, there is a human element which is probably a governing factor. This human element is the man who actually does the feeding. The man who mixes the feed and carries the feeding pail is a dominant factor in the success or failure of any ranch. A good ration can be put to efficient use by a good feeder, but it can be ruined by poor feeding practices. A moderately good ration, likewise, can be put to efficient use IF it is fed properly.

It has been demonstrated many times over that the identical ration fed in as nearly the same manner as possible, even on neighboring ranches, will give different results. The effect of the nature of the animals, the environment, climate, nature of the feeder and many other factors all combine to give a great variability of results with the same basic dietary components.

For such reasons as these alone, it would not be advisable for any one individual to attempt to set down definite ration formulae

which could be guaranteed to give success every time under any conditions. Immediately there would be repercussions!

Furthermore, the availability of raw materials, mainly in the meat category, will be a deciding factor in developing the formula. We cannot expect a rancher living along the sea coast to pass up his natural supply of ocean fish, just because someone says that the diet should contain a certain percentage of horse muscle meat. Neither can we expect the rancher in an isolated area to always feed a diet with a fixed percentage of some definite ingredient. In other words, the possible variations cannot be overcome in attempting to indicate a suitable diet for all purposes.

With this in mind, therefore, the following data on various formulae and schedules cannot meet with the approval of everyone everywhere, and they are set down here merely as a guide—an indication of what others have been doing.

During many years of experimentation in the field of mink nutrition, various ration modifications have been tested. The general, all-purpose ration, indicated below, has been found to give good pelt production and to maintain pelters and breeders alike in good condition throughout the year. Litters have always been of normal size, losses of kits have been at a minimum and there was a very low mortality rate among adults. None of these losses was directly attributable to the ration fed. The only change that was made in this diet during the course of the year was the substitution of a slightly larger percentage of visceral meats from about July 1 through November 30. This applied to animals being carried over for the next breeding season as well as those destined for pelting. During the remainder of the year, the allotment of raw horse meat was increased with a correspondingly lower usage of viscera:

Ground horse meat Viscera	47.5 per cent
Ground green bone	5.0 per cent
Fresh liver	10.0 per cent
Cooked fish	15.0 per cent
Commercial cereal (cooked)	16.0 per cent
Fresh vegetables	5.0 per cent
Dried brewers yeast	1.0 per cent
Cod liver oil	0.5 per cent

A study was also made of various rations submitted by ranchers in all parts of the country, the largest number being from mink raisers in the Middle West, and the general trend shown was about as follows:

For general all-purpose rations (i.e., approximately the same formula fed all year round), the general range of horse meat content varies between the wide limits of 32 and 77 per cent. This may appear rather too broad, but it must be remembered that in those cases where the percentage of meat is low, the percentage of fish was

generally high and vice versa. The great bulk of the figures fall within the range of 45 to 50 per cent horse meat.

Almost all rations were found to contain about 5 per cent of ground green bone.

With respect to the content of liver, the variations are small. The lowest figure encountered, with the exception of three ranches which did not use this material, is 3 per cent, while 10 per cent appeared to be the top limit. Various ranchers had tried to use more than 10 per cent of fresh liver but found that their animals suffered too much from looseness of the bowels. Several of the ranchers reported that they were using dehydrated liver with apparently good results at levels between 2.5 and 3.5 per cent.

The content of fresh vegetables in the diets varied between 3 and 7 per cent, the average being 5 per cent. This is considered a desirable level for mink when vegetables are used in the ration.

The level of cereal in the ration showed variations between 15 and 25 per cent. The great majority of the figures were about 16 per cent, and this latter is considered a fair level for all-purpose rations.

Coming back again to the meat items of the ration, it was observed that the general usage of visceral meats varied between 10 and 25 per cent, with the general average being about 12.5 per cent. As mentioned previously, there appeared to be an inverse relationship between the usage of horse meat and fish. The fish usage varied between 15 and 45 per cent. In 95 per cent of the rations from the mid-western states, the fish was cooked, while others were using it on an alternating schedule, feeding fish one day and omitting it the next. In rations from ranches in the eastern and western parts of the country, the general usage of fish was found to be considerably higher and, since these were usually ocean fish, the great majority were fed without cooking.

Dried brewers yeast was found to be in rather general use at a level of 1.5 to 2 per cent of the diet. The percentage of cod liver oil in most rations varied between 0.5 and 1.

In summary, this would present the following picture:

Horse meat	32 to 77 per cent
Visceral meats	10 to 25 per cent
Fish	15 to 45 per cent
Liver	3 to 15 per cent
Ground green bone	5 to 8 per cent
or steamed bone meal	2 per cent
Vegetables	3 to 7 per cent
Commercial cereal (cooked)*	15 to 25 per cent
Dried brewers yeast	1.5 to 2 per cent
Cod liver oil	0.5 to 1 per cent

* The cereal mixture was a cooked and processed commercial cereal in 93.5 per cent of the cases studied.

It was found extremely difficult to divide the year into suitable divisions so as to be able to indicate diets for use during the breeding, gestation and lactation periods and during the season of feeding animals destined for pelting. However, a rough approximation of the composition of diets used during these periods was made. In addition to a wide variety of formulae used, there was also considerable discrepancy noted as to just what is the proper division of the year from the standpoint of a consideration of diet formulae. The following table, however, presents a grand average of diets for the so-called breeding and whelping season, arbitrarily set as from December 1 through July 1. This same schedule will hold through until about September 1 for kits born in the spring, and therefore, in the process of attaining full growth.

AVERAGE DIETS IN USE

	Breeding and Whelping %	*Pelting* %
Horse meat	40 to 60	15 to 30
Viscera	10 to 15	25 to 45
Liver	10 to 15	5 to 10
Ground green bone	4.5 to 8	5 to 8
Fish	0 to 15	10 to 15
Vegetables	4 to 5	5 to 6
Commercial cereal	7 to 18	20 to 25
Dried brewers yeast	2	2
Cod liver oil	0.5	0 to 0.5

On the basis of the information immediately above, it would appear that the greatest change in diets between those intended for breeders and those destined for pelting, is in the content of the cereal part of the diet. In every case used in this compilation, the cereal was a commercial, cooked and processed material. A few ranchers were using cereal mixtures with added meat by-products for feeding pelters, though it was not possible to indicate the percentage here. On the basis of these surveys, it is seen that commercial cooked and processed cereals are generally used in the ranch raising of mink. One reason for this probably lies in the fact that the cooked and processed commercial cereal mixtures contain a higher percentage of digestible carbohydrates than would home-mixed cereals. This factor appears to be most important in the consideration of what cereal to use in the mink ration.

HELPFUL HINTS — GENERAL

Rancher —We have just received our first carton of frozen "treated" sheep liver for fox feed. This material is dyed green, but appears to be covered with a fine white mold. Should we feed this or not?

Answer —The sample which you sent has been tested bacteriologically and we can find nothing the matter with it, and therefore, would consider it safe for use. The green dye which you mentioned is harmless and is applied by the packer of the product. It is a vegetable dye. (Later, a visit was made to this ranch and the "white mold" referred to was demonstrated to be simply due to moisture which had condensed on the surface of the liver and frozen as very small ice crystals). This is commonly seen on products which have been in a freezer for some time.

Rancher —How should I store cod liver oil?

Answer —First of all, do not purchase too large a quantity at one time. It is better to buy in small lots to ensure getting fresher stock from the supplier even though the cost will be slightly higher. The oil should be stored in a refrigerator at all times when not in use. It should preferably be stored in tightly closed, amber glass bottles or cans. Upon exposure to light and air, cod liver oil will become rancid and its vitamin A potency will decrease markedly. Such oil that has been unduly exposed should not be fed.

Rancher —What are the best natural sources of vitamin K? How are units of this vitamin properly expressed?

Answer —Alfalfa, kale, spinach, cabbage, tomatoes, pork liver, soy bean and some other vegetable oils are considered the best sources of vitamin K. There are no "units" in use for this vitamin at the present time. It is most common to express the vitamin potency on a weight basis, i.e., so many milligrams of vitamin K per 100 grams of material.

Rancher —Why is so much emphasis placed on liver in fox and mink rations? Is it really as valuable as claimed?

Answer —The feeding of liver has received emphasis because it is one of those relatively rare dietary items which contains a host of valuable nutrients. It is valuable because it contains important amounts of many vitamins, is rich in essential mineral elements, usually contains about 5 per cent of fat and some 18 to 20 per cent of protein of high nutritive value. It also has mild laxative properties, and when you find the correct level for the best balance with the other constituents of your diet, you will keep the bowel

movements in good order. In addition, it is a rich source of possible, unknown nutritional factors. Its importance and significance as a food ingredient for foxes and mink is unquestioned. It is valuable!

Rancher —What can be suggested in the way of substitutes for fresh liver? I am not very much impressed with any substitutes known to me.

Answer —The best answer appears to be that there are no good substitutes. Probably the most practical thing with which to replace liver would be spleens (melts) if you want to use a fresh meat. However, do not construe this statement to mean that spleens and livers are interchangeable or that spleens are the nutritional equivalent of liver. Among other possible substitutes are liver meal and dehydrated liver. The former, however, is a group name and the product sold as liver meal may not actually contain much liver. On the other hand, dehydrated liver and liver meal coming from South America may be a suitable substitute though no carefully controlled experiments have been made with it. At the present time they are probably too scarce and high in cost to be useful.

Rancher —Of what value is salt in fox and mink feeds? How much should be used? Can I feed too much salt?

Answer —The complete role of salt in fox and mink nutrition is unknown, although it is known to be required for normal body function. A small amount also tends to increase the palatability of the diet. One-fifth of one per cent is adequate though both foxes and mink will tolerate more. Though no experimental evidence with fur animals exists to indicate the maximum that can be used, excessive amounts will tend to make the ration unpalatable. It should also be borne in mind that the addition of salt will increase water consumption, so you would be well advised to provide for a larger supply of drinking water than normal if you use a large amount of salt.

Rancher —I am using a large amount of vitamin concentrate in my fox and mink diets. Is there any danger from feeding too much vitamins?

Answer —Generally speaking, most fox and mink rations are composed of a large variety of products of animal and vegetable origin. Because of this, it is most probable that the amount of vitamin fortification required is lower than would be the case if the composition of the diet were less complex. However, as a safety measure and until we know more about the vitamin requirements of these

animals, we have seen fit to advocate the addition of vitamins A and D in cod liver oil and the B-complex vitamins as found in yeast and liver over and above those amounts found in the other components of the diet. There is apparently no danger in feeding large amounts of thiamine (vitamin B_1) or riboflavin (vitamin B_2 or G). In connection with thiamine, it might be well to point out that requirements for this vitamin will vary with the energy requirement of the animal. An inactive fox or mink will thus need less than a very active animal. It is also known from experiments with certain laboratory animals that a diet high in fat will lessen the thiamine requirement—this commonly being referred to as a "sparing" action. This has not been demonstrated for foxes or mink, however, although it is assumed to be true. Increases in requirement varying between 15 and 80 per cent have been recorded due to various causes. One of these which increases thiamine requirement is diarrhea. The results from overfeeding of vitamins A and D, however, may be quite another story, since these vitamins have been shown to be toxic in very large doses. The specific effects of overdosage with vitamin A tend to be rather obscure. However, excessive amounts of vitamin D may cause a loss of appetite, lowered milk production, bloody diarrhea and a general listlessness on the part of the victim. It has also been demonstrated that there can be rather severe and widespread calcification occurring in unusual places in the body such as the lungs, heart, stomach, kidneys and even in some muscles.

Rancher —What temperatures would be best for freezing meats as well as for holding meats frozen for long and short periods of time?

Answer —Freezing of meats can be accomplished satisfactorily at about 10 to 15 degrees below zero Fahrenheit, if the material is in shallow pans or spread in thin layers, say two or three inches in depth. On the other hand, if the meat tends to be in large pieces where the relative thickness will vary, temperatures below minus 15 degrees are preferable. The main thing is to ensure rapid and *complete* freezing so that there is no unfrozen area in the middle. Some even prefer to freeze all meat at temperatures ranging from 20 to 25 degrees below zero. Once the material has been sharp frozen, it can be held at temperatures between zero and 15 degrees above for long periods of time—say 7 to 8 months—and perhaps longer. In the event that meat is to be held for long periods, it is advisable to wrap it or spray it with water and freeze further to produce a glaze. This will prevent the meat from

drying out and becoming subject to "freezer burn." If the holding is only a matter of a few days or so, the temperature in the meat cooler should be in the vicinity of the freezing point, say between 32 and 34 degrees Fahrenheit. Do not interpret the first statements made about freezing to mean that temperatures colder than 20 to 25 degrees below zero cannot be used. Sharp freezing can be done at any suitable temperature below the range indicated if you can get that temperature.

HELPFUL HINTS FOR THE FOX RANCHER

Rancher —My male foxes seem to be alert and very active in the early part of the breeding season, but after mating a couple of females, they will not breed any more. This was very discouraging but my feed man told me that I should get some vitamin C and put it in capsules for them. I did so and some of the males started in breeding again after the first capsule while with others it took four. However, every fox that I gave it to started breeding again and worked right through till the end of the season. The net result was that I had only four blanks out of sixty females. What do you think of this sort of treatment? Can it cause harm?

Answer —It is agreed that very little is known about the functions or possible requirements of vitamin C for foxes. The observations of this rancher are interesting, since the winter previous to this particular breeding season was mild and it is possible that mild weather may lessen the desire or ability of the male to mate. The administration of vitamin C in such cases might be a good suggestion. This one report does not appear to be conclusive evidence, since it was uncontrolled, though the possibility of using vitamin C for this purpose certainly looks intriguing. There is probably no basis, at the moment, for a blanket recommendation of vitamin C therapy every year but you and others might be well advised to make a note of this observation and, if breeding trouble is encountered, give it a trial with those animals refusing to work. Certainly it can do no harm and the cost will not be excessive. The amounts of vitamin C given in this particular instance was not indicated but 100 milligrams at a time should be adequate for the purpose.

Rancher —At what time of day should I feed my foxes?

Answer —During the cool days of fall and spring, feeding can best

be done in the middle or late afternoon. In winter, time is not so much a factor and feeding can be done almost any time during the afternoon, although it is wise to follow approximately the same schedule each day. In summer, it is preferable to feed in the cool of the evening, in fact, the later the better.

Rancher —My production of fox pups is not as good this year as it has been. Those foxes which do have litters average better than five but there are about 38 per cent of blanks. Judging from the following formula, do you think we are feeding our foxes too much bone with the meat? If large amounts of bone are fed, would this result in failure of the animals to breed? Our formula is as follows: 70 per cent meat and green bone, 15 per cent cereal, 10 per cent commercial mineral compound, 5 per cent vegetables (lettuce and celery mainly), and a small amount of cod liver oil.

Answer —Many ranchers are successfully feeding horse meat and bone ground together. Bone with meat from horses will not throw the ration seriously out of balance insofar as we know, and it should not interfere with reproduction. We do not know the nature of the commercial mineral compound but, inasmuch as your diet is otherwise conventional, the addition of such large amounts of additional minerals makes the total mineral content of the diet too high. It is suggested that the ration you have indicated be modified slightly to include up to 10 per cent of fresh liver, 1 to 2 per cent dried brewers yeast and 0.5 to 1 per cent cod liver oil. At the same time the commercial mineral compound should be reduced in quantity, if not eliminated entirely.

Rancher —My foxes begin to show some tinge and their color goes off during the month of September nearly every year. This loss of color seems to progress only to a certain point and then stops there. At the same time, there are certain spots on the back and across the rump, over the shank, where the fur becomes very badly rubbed. What could cause a condition like this?

Answer —This is a very complicated problem and without a study of the ration which you are using, of course, anyone would hesitate to say that there could be anything wrong with your diet. These conditions of tinge and rubbing may be due to any one or more of a number of conditions and it is likewise possible that they may be of entirely different origin.

Rancher —Do you consider it advisable or necessary to make any

changes in fox diets during the periods immediately prior to and following mating?

Answer —If you make a study of rations used on many ranches and ask the opinions of ranchers you will find about an equal number of "yes" and "no" answers. This question is one which cannot receive a definite recommendation at the present time. It has been the experience of many that, using a diet which is complete and well balanced, insofar as it can be so made, there is no need for a change of diet. However, if a change is to be made prior to mating it would be advisable to increase the meat protein including liver (fresh or dried) and reduce the cereal slightly. The reasoning behind such a change is that a diet slightly richer in meat prior to mating seems to have a stimulatory effect on reproductive functions. After mating, you will again find a variation of opinion. The important thing is to be sure that the bred females are well nourished both in quantity and quality of food. Some ranchers feel that, after mating, the diet for females should contain a little less meat and bone than normal since this will tend to prevent development of too large fetuses and thus reduce the difficulties encountered when whelping time comes around. However, there is no proof for this latter claim as far as is known.

Rancher —I have seen many figures and heard many arguments, both pro and con, but would like an opinion as to how much bone there should be in a fox ration prior to whelping.

Answer —Since there is apparently no proof for the contention that feeding larger amounts of bone causes larger pups and difficulties in whelping, there is no necessity for changing from the regular formula with regard to bone content. Five per cent ground green bone or 2 per cent steamed bone is adequate. Good commercial cereals contain adequate amounts of steamed bone meal when used at recommended levels.

Rancher —I have noticed that fox pups start to eat solid food at about four weeks of age. Would it be possible to wean them then?

Answer —Although you have noticed pups eating solid food at this early age, if placed in separate pens there is danger that they might fail completely. It is a much safer practice to continue to let them nurse and have access to some solid food at the same time as a supplement, so to speak, until they are about eight weeks of age. This is early enough for most animals.

Rancher —I notice that one to two per cent dried brewers yeast is usually recommended in fox rations. Can too much be fed and what are the symptoms of overfeeding it?

Answer —No ration in common use today should require more than two per cent. If the diet contains much liver, amounts less than two per cent are suitable. There has been no satisfactory correlation made between "symptoms" and an excessive amount fed in the diet, but it has been observed that with three or five per cent in the ration, the diet apparently becomes rather unpalatable. Because of this, animals will eat less and, therefore, defeat one of the purposes of feeding yeast, namely, as a valuable source of B-complex vitamins (mainly thiamine) and also as a stimulator of appetite.

HELPFUL HINTS FOR THE MINK RANCHER

Rancher —I am a beginner in the mink business, but of course want to get started right. My animals are in good shape and quite active, but their stools are a trifle soft. I lay this to the eggs I am feeding. The daily feed contains 4.5 pounds of frozen meat, 0.5 pound of cereal, 1 ounce of bone meal, 1 ounce of dried brewers yeast and 0.5 ounce of dried whey. To this I add half a pint of whole milk and some wheat germ oil, all of which is mixed with two well-beaten eggs. This mixture is then poured onto the solids and mixed well. The "frozen meat" above contains also 5 per cent vegetables and 10 per cent liver, lungs and hearts. This is all ground together with horse meat and frozen in molded blocks. The amounts required for each day are thawed out as required. The breeder from whom I purchased my animals recommended feeding eggs for good production of kits and increased litter size. What comment do you have to make on the above?

Answer —The looseness of the stools to which you refer may be the result of one or more of a number of things. It is possible that the animals were having this trouble before you got them and they may not yet be accustomed to the feed you are giving them. By calculation, this diet contains too little cereal and it is suggested that you use about 16 per cent of cereal in the mixture without counting the water or milk used to make the feed to volume. It is also possible that the combination of eggs, milk, liver and whey is too laxative for your animals and it is suggested that you eliminate the whey for a short period of time and see

whether the condition clears up. It is also noted that your ration does not contain cod liver oil and it is suggested that you add about 0.5 per cent. Wheat germ oil is not considered necessary where a good commercial, cooked, processed cereal is used. It is suggested that you try a diet of the following percentage composition: 66 per cent horse meat or other meat and bone, 10 per cent fresh liver, 5 per cent fresh or canned vegetables, 16 per cent cereal mixture, 2 per cent dried brewers yeast and 0.5 to 1 per cent cod liver oil.

Rancher —I have a 100-female mink ranch and yesterday a female died that had given birth to a litter of five kits and raised them all. Upon examination, I found that one kidney was wasted away to practically nothing and the other was completely impacted with a solid deposit. What could be the trouble? My diet consists of the following: 70 per cent horse and other meats, 15 to 20 per cent commercial mink cereal, 5 per cent of tomatoes every other day, 3 per cent of a commercial yeast vitamin concentrate, 5 per cent of steamed bone meal and 7 per cent of cooked oatmeal.

Answer —Apparently, you have a case of kidney stones and/or urinary calculi which may arise from a number of causes. Most of the experimental evidence indicates that it may be due either to vitamin A deficiency or to improper balance of calcium and phosphorus. In view of this, it is suggested that you feed 1 per cent cod liver oil. Five per cent of steamed bone meal is too much and it should be reduced to at least 2 per cent. The 7 per cent of cooked oatmeal should be eliminated.

Rancher —At the present time I have 20 mink of good quality, but I notice loose bowel movements every three or four weeks and most of the animals go off feed for several days at a time. Perhaps you can tell me what the trouble is. The ration consists of the following: 4 pounds of horse meat, 7 ounces of liver, 1 pound of commercial cereal, 3 ounces of commercial vitamin concentrate and 8 ounces of vegetables. I feed carrots one day and tomato juice the next. I add a couple of eggs every other day and also a little salt. I think that this diet is unbalanced, but I can't tell where.

Answer —It is suggested that you try eliminating the liver one or two days a week and see if this will eliminate the loose bowel movements. (This rancher later stated that this simple diet change was made and that symptoms of loose bowels disappeared and the animals stayed "on feed.")

Rancher —Every winter I have some mink with sores on their heads. The face swells up and they stop eating for a day or so and then the sore breaks open and drains. I haven't lost any mink from this condition but would like to prevent it, if possible. Some ranchers say it is from burrs and stickers in the hay. Have you any further explanation or comment?

Answer —The trouble with boils on the head of a mink is not uncommon. The exact cause of these sores is not known but there may be different conditions involved in their occurrence. Assuming that hay used in nesting is the main cause of boils, it appears that small, sharp spicules of hay work their way up between the teeth and into the flesh on the side of the head. Here they start to fester and pus accumulates. When the pressure becomes great enough, the boil breaks and drains. When some such boils are lanced, spicules of bone may be found. If the boil fails to break, it should be carefully lanced with a sharp knife, cutting vertically so that the drainage will not be obstructed. Disinfect the boil area with mercurochrome or swab it with tincture of iodine. When the lancing is complete, again swab the area with tincture of iodine. It is suggested that you use the best high-grade marsh hay for nesting, containing a minimum of weeds. If you find that your trouble is from pieces of bone in the feed, the simplest remedy is to grind the bone finer.

Rancher —I am taking the liberty of writing you about bladder stones in mink. For the past five years I have had females die just prior to having their young, and upon examination, they had large bladder stones which I believe interfered with whelping. My losses from this trouble usually run about 5 to 7 per cent. At other times of the year I do not have any trouble. My ration is as follows: 15 per cent commercial cereal, 2 per cent tomato pulp, 3 per cent horse and beef liver, 35 per cent horse meat, 10 per cent fish racks, 5 per cent tripe and 30 per cent water.

Answer —The conditions on your ranch appear to be rather typical of the general symptomology of bladder stones in mink as they have been observed in the past. Like many others, you have noted the greatest losses just prior to whelping. Your diet appears to be quite satisfactory, though it is recommended that the fish racks be cooked if at all possible. It is considered possible that your bladder trouble may be due to an improper ratio between calcium and phosphorus but an analysis of your ration must be made to determine this. Then a more concrete suggestion for

remedy could be made. It is recommended that you add about 1 per cent of cod liver oil to your diet.

Rancher —Is much soybean oil meal being used as a replacement for meat in mink feeds?

Answer —Replacement studies of this nature have been rather limited and usually were conducted with small numbers of animals over short periods of time. While soybean oil meal is an excellent protein from the nutritive standpoint, it is not widely used as such. Some commercial cereal mixtures contain it, however.

Rancher —Is the chief benefit of liver for feeding mink due to its vitamin A content?

Answer —The chief value of liver feeding does not lie in its vitamin A content. It has long been the finding of nutrition workers that liver itself is an excellent protein source, the protein being of high biological value and good amino acid balance. In addition, it is a rich source of some of the well-known vitamins and a number of as yet unidentified growth factors. It is important to remember that liver is a good all-round feed ingredient since it has exceptional value in so many respects.

Rancher —In our efforts to find cheaper eggs for mink feed, we found that a hatchery near us sells infertile eggs at a very low price. These eggs have been in a incubator and, except for occasional blending of yolks and whites, seem to be perfectly all right. What is the comparative food value of these eggs versus fresh eggs? Is it advisable to feed them in a mink ration?

Answer —Tests have indicated that there is no nutritional difference between infertile eggs and the fresh product and they make excellent mink food. If you are assured of an adequate supply, use them as they become available. If possible, you might also obtain supplies greater than your current requirements and break and freeze them in shallow pans, about two inches in depth, for future use. Make sure that they are maintained in the frozen condition until used. It is suggested that you use no more than half an egg per mink per day.

Rancher —What do you consider the proper age for weaning mink kits?

Answer —There are several things that should be taken into consideration. The date of whelping, number of kits in the litter, the condition of the female and general management and environmental factors are all concerned. If

the litter is born early in the season, it might be preferable to leave the young with their mother a little longer than normal. If the litter is very large and it appears that the female will not have enough milk for all the kits, the strongest ones may be removed a little earlier than the remainder of the litter. Generally speaking, weaning should be completed as soon as the young are able to care for themselves. Inasmuch as the digestive tract of the mink is fully developed within seven or eight weeks after birth, the kits should be able to eat regular mink feed by that time and this is generally considered the best weaning time.

Rancher —I am feeding a mink ration consisting of horse meat and fish 10.5 ounces, commercial cereal 4.5 ounces and tomatoes 1.5 ounces. I mix the cereal with milk, then add meat, fish and tomatoes, plus a little liver now and then. My females had young all right but did not raise them. Is this the fault of the diet I am using?

Answer —By calculation, your ration consists of approximately 64 per cent horse meat and fish, 27 per cent cereal and 9 per cent vegetables. This does not count the milk used to make it to volume. While it contains good materials, certain supplements might be valuable. It is suggested that you use a variety of meat items—horse meat, beef trimmings, rabbits, hearts, etc. If you are grinding green bone with your horse meat, continue to do so but, if not, it is suggested that you include 2 per cent steamed bone meal. The cereal portion of the diet is somewhat higher than necessary unless it contains some meat by-products. If it contains none, it is suggested that you decrease the cereal to about 16 per cent. The 9 per cent of vegetables will not do any particular harm but 5 per cent is generally considered sufficient. You could also improve your diet by feeding 2 per cent brewers yeast, 1 per cent cod liver oil and a small amount of salt—about one-fifth of one per cent. You might like to use the following as a rough guide: horse or other meat 54 per cent, fish 15 per cent, liver 10 per cent, commercial cereal 16 per cent and vegetables 5 per cent. It is also suggested that you might use fish being sure to follow recommended procedures when using the fish raw.

Rancher —My daily mink diet consists of the following ingredients: 70 pounds of fish, 25 pounds of tripe, 7 pounds of beef head meat, 3 pounds of cereal, 1.5 quarts of skim milk, 0.5 cup of cod liver oil, 1 cup of tomato juice, 0.5 cup of commercial tomato product every other day and 1 whole spleen per day. How about it? Good, bad or indifferent?

Answer —This ration might go along all right for awhile, but there may be serious trouble. It is suggested that you cut the amount of fish in half and do likewise with tripe and then use red meat to make up the difference. The amount of cereal is too low and should be raised to about 16 per cent of the total ration (that is, 16 per cent before the addition of water.) It is suggested that the cod liver oil level be raised to 1 per cent of the diet and that the tomatoes and commercial tomato product be included such that their total will be 5 per cent of the diet. The use of spleens is all right but one alone will not do much good and cannot replace liver completely. Your diet should contain about 5 per cent of fresh liver. It has been suggested that you cut the amount of fish fed in view of the possibility of encountering thiamine deficiency (Chastek Paralysis). However, this is under the assumption that your fish are of certain species and that they are fed raw. If they are cooked or if you feed homogenized condensed fish, the situation will be quite different, Most ranchers have found the feeding of raw fish most satisfactory when it is done at stated intervals with days in between when no raw fish are fed. In spite of this comment, however, it is thought that the fish content of your diet is excessive.

Rancher —Do you consider anemia in mink to be a serious problem? I have heard a lot about the condition and would like to have your opinions.

Answer —It goes without saying that the occurrence of anemia is to be considered serious but, at the present time, we know of several different types and causes of an anemic condition. However, it is very difficult to say whether many conditions commonly called anemia in mink are really anemias. Preliminary work on the determination of the chemical composition of mink blood has been begun, but until such time as a more comprehensive picture of the blood of these animals is available, it is going to be difficult to interpret correctly many of these so-called anemias. One must remember that anemia may be the result of any one of several different types of deficiency diseases and may be of any one of several forms. These circumstances, coupled with our lack of knowledge of what is the blood normal for mink may make it very difficult to assess the true importance of anemias in fur-bearing animals.

Rancher —Is there any scientific evidence that vitamin E and similar substances will help prevent "misses" in mink?

Answer —Despite the popular belief, there is no scientific evidence for this statement with respect to mink.

Rancher —Do you consider it necessary or advisable to make changes in mink rations during the period just before or after mating?

Answer —Generally, no changes are necessary either before or after mating if the ration is basically good. However, some diets might be improved by reducing the cereal slightly and reducing the usage of meat by-products such as tripe. Raw meat should be substituted for these. It may also be advisable, during the time before mating, to increase the liver content of the diet to a 10 per cent level. After mating, no additional changes need be made.

Rancher —What kind of yeast should I feed my mink and how much do you consider advisable?

Answer —Use a product known as dried brewers yeast or killed yeast cells and avoid using live yeasts. Dried brewers yeast may usually be obtained in either of two forms, debittered and non-debittered. The latter is quite satisfactory for fur animal feeding and costs less than the debittered variety. One to two per cent in the ration is adequate for mink. By this is meant that 1 or 2 per cent before the addition of water or milk to bring the ration to feeding consistency.

Rancher —How much liver should be fed to mink? What diseases will be cured or alleviated by feeding it?

Answer —Some experiments have shown good results using 10 per cent of the diet as liver. However, some people seem to feel that 10 per cent liver is too high and that it should be reduced to 5 per cent. This does not mean that 5 or 10 per cent is an absolutely necessary minimum since it may be impossible to procure this amount all the time. However, it is recommended that you use all you can up to the figures indicated. Lest you come to think of liver as a remedy or a cure for everything, rest assured that liver is no cure-all for diseases. However, its inclusion in the diet will serve to help correct a large number of possible nutritional deficiencies due to unknown qualities of raw ingredients. Inasmuch as these may result in specific deficiency diseases, liver may be regarded as a preventive for them, but not for diseases as a whole.

Rancher —How can I tell whether my mink have stones in the kidneys or urinary calculi? What are the causes of calculi?

Answer —Generally, it has been found that mink suffering from urinary calculi show few symptoms. They usually appear all right one day by casual examination and yet, may be dead the next day. Such symptoms as an unnatural gait

with spreading of the hind legs and excessive nervousness have been recorded. It is also possible that there may be a partial paralysis of the hind quarters and sometimes skin irritation under the belly due to irritation from the dribbling of the urine. According to best information, there are several possible causes which have been suggested. Among these are: a generally incomplete and unbalanced diet, excessive feeding of mineral supplements, disturbances of hormone balance, vitamin A deficiency, infections of the urinary bladder and also, there is a possibility that there is an inherited tendency towards this condition.

Rancher —I have been feeding a lot of fish to my mink just prior to pelting and my results have not been too good this year. Should I use more or less than half the meat portion of my diet as fish?

Answer —There is no hard and fast rule saying how much fish can or cannot be used safely. Generally speaking, if we consider that 70 to 75 per cent of the mink ration is meat (before adding water) it is suggested that not more than 20 per cent of this should be fish. This means a total of 15 to 20 per cent of fish in the diet. If these fish are from fresh-water sources it is felt that they should be cooked or fed only at intervals in accordance with suggested schedules. There are reports, however, that where the greater portion of the mink diet was fish all year round, production and pelting records were always satisfactory. It is considered a matter worthy of test but your judgment must be your guide at the present time.

Rancher —How can I prevent tail chewing in my mink? My rations contain horse meat, cereal, skim milk, and water with some fish occasionally. I am also feeding carrots and tomatoes as available.

Answer —As you are no doubt aware, many causes have been postulated for tail chewing. This condition may be inherited or may be due to extreme nervousness but has also been suggested as due to various dietary deficiencies; among the factors blamed has been a deficiency of fat. It has also been observed that moving animals around from one pen to another may serve to stop it in some instances. The feeding of additional amounts of vegetables has also been recommended. The diet which you have suggested contains no liver or brewers yeast and you do not give the proportions of the various ingredients used. It is suggested that the amount of cereal in your diet be about 16 per cent, that you use about 5 per cent vegetables, 1 to 2 per cent dried brewers yeast and 0.5 to 1 per cent cod

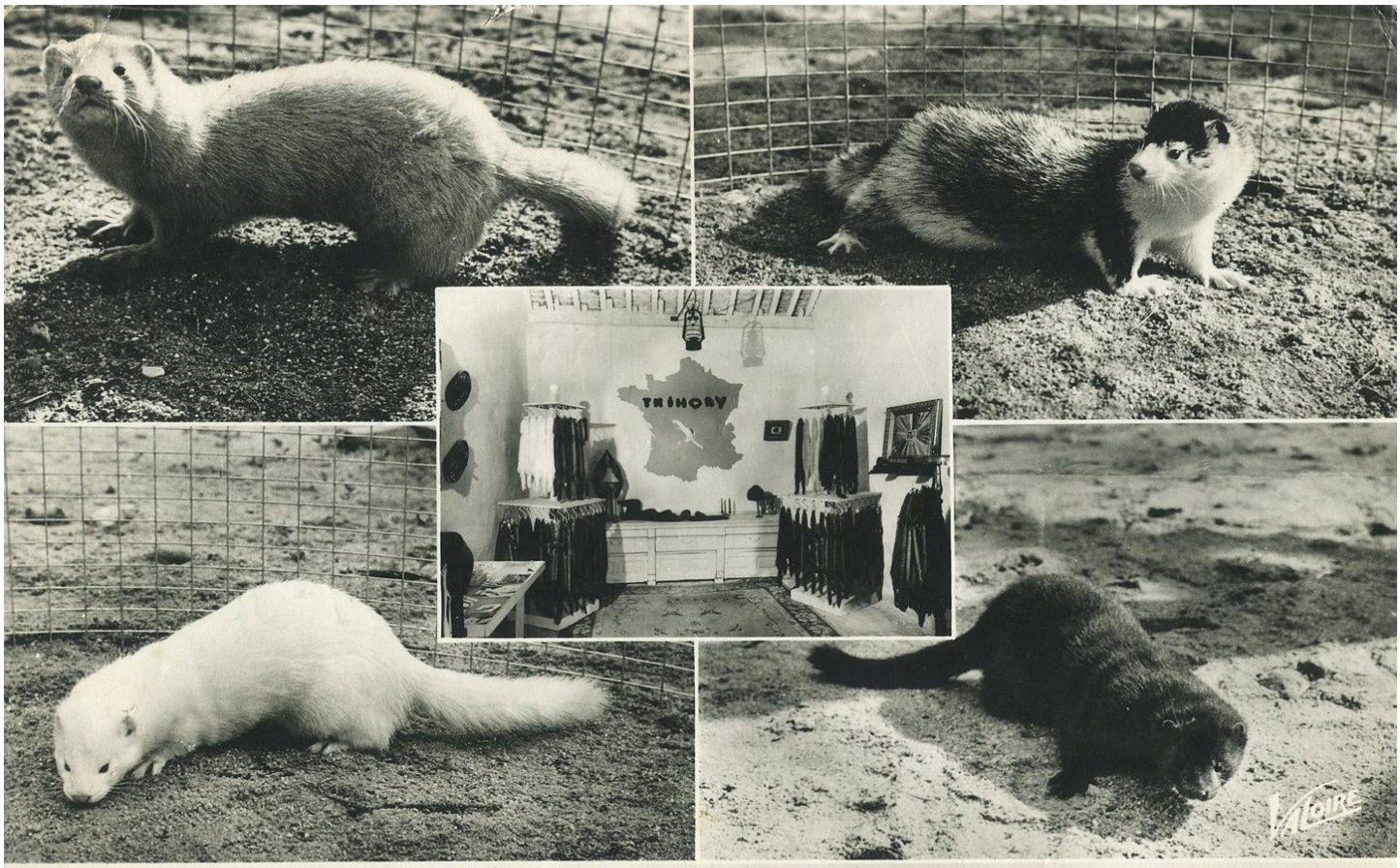
liver oil. (About one month later, this rancher reported that his animals had improved and indicated that the incidence of tail chewing had dropped markedly. He expressed the opinion that ration changes had remedied the situation though he had made so many alterations at one time that it was impossible to credit any one factor with the better performance of the mink.) It has been reported more recently that some cases of tail chewing may be stopped by squeezing the scent glands on either side of the rectum which will relieve an occlusion or blocking of these glands. This blocking of the glands may cause an irritation at the base of the tail.

Rancher —Inasmuch as I have only a few mink, I want to save time mixing a batch of feed every day. I would like to mix a large batch all at once and wonder what would be your opinion about making up enough feed for a couple of weeks—meat, cereal, vegetables and all—and then freezing it all together. Then I could thaw out what I need for one day and refreeze the remainder. Would you consider this a safe practice?

Answer —While your efforts to conserve labor are appreciated, this practice is definitely considered an unsafe one. This continual thawing and freezing is not a safe procedure since it permits access of bacteria each time the thawing is done. This means that the total bacterial load carried by the feed will be continuously increasing and may eventually reach a point where the feed will become definitely harmful to your mink. Such a procedure as this would not be recommended by experienced ranchers or advisors.

GLOSSARY

Anti-oxidant —	Prevents oxidation.
Bile —	A yellow or greenish fluid secreted by the liver; aids in the digestion and assimilation of fats.
Carbohydrates —	Are compounds containing no nitrogen, but only carbon, hydrogen and oxygen. Usually thought of as being simple sugars, but also include starch, pentosans, gums, cellulose and related substances.
Carotene —	The vitamin A precursor found in the plant kingdom.
Epizootic Disease —	Affecting many animals (of the same kind) at the same time.
Hemoglobin —	The red coloring matter of red blood cells; essential for carrying oxygen to the tissues.
Spastic Paralysis —	A steady uniform muscle contraction. Sometimes caused from thiamine deficiency which in turn was caused from feeding raw fresh-water fish.
Telang Livers —	Packing house term for livers characterized by enlargement of the terminal blood vessels—condemned for human consumption but all right for animal use.
Tripe —	The lining of the first and second stomach from clovin-hoofed animals.
Urinary Calculi —	The stones (mineral deposits) deposited in the urinary bladder generally thought to be a vitamin A deficiency. The exact cause is not definitely known.
Vitamin D_2 —	From irradiated ergosterol, is active for the rat—has low chick activity.
Vitamin D_3 —	From irradiated 7 dehydro-cholesterol—the most effective form of vitamin D for poultry.



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